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12th Floor East Tower
Centre Square
1500 Market Street
Philadelphia, PA 19102
215.246.3447 PHONE
215.665.5748 FAX
www.TRCsolutions.com

Memorandum

Date: May 28, 2013

Ref: CERCLA Docket No. 02-2010-2017; Shieldalloy Metallurgical Corporation Superfund Site - Newfield, NJ

To: Sherrel Henry, EPA RPM

cc: Donna Gaffigan, NJDEP; Ed Modica, EPA

Subject: **SMC MNA Model**

INTRODUCTION

TRC has been implementing an In-Situ Remediation Pilot Program at the Shieldalloy Metallurgical Corporation (SMC) Site for 5 years. The In-Situ Remediation Pilot Program has included the acceleration of aquifer cleanup via aggressive injections of calcium polysulfide (CPS), which was supported through extensive "proof-of-concept" laboratory studies and field pilot tests. Injections of CPS performed at the SMC Facility during 2011 and 2012 successfully reduced dissolved chromium concentrations below the 100 microgram per liter (µg/l) EPA cleanup criterion in groundwater beneath the vast majority of the SMC Facility. Injections subsequently performed at the Farm Parcel in 2012 also resulted in significant reductions of chromium concentrations in groundwater. Supplemental injections are being performed during the summer of 2013 to further reduce residual dissolved chromium concentrations at the Farm Parcel and at the Car Wash Area immediately downgradient of the facility. Supporting studies and testing performed by TRC demonstrate that chromium reductions in groundwater are stable and persistent.

The In-Situ Remediation Pilot Program has also included a systematic evaluation of Monitored Natural Attenuation (MNA). The MNA evaluation presented in TRC's February 14, 2013 *"Procedural Assessment of MNA of Chromium in Groundwater at the SMC Site"* memorandum, (including response to comments/addenda) assesses the efficacy of MNA in accordance with EPA's "4-Tier" approach (described in EPA's October 2007 guidance document entitled "*Monitored Natural Attenuation (MNA) of Inorganic Contaminants in Ground Water*"). The February 14, 2013 memorandum addressed the first three Tiers of EPA's approach and concluded that MNA is viable[1].

Regulatory input indicated that further study of MNA is warranted to build upon current MNA knowledge at the Site. Additional study activities include the collection of groundwater data under "non-pumping" conditions, which began in April 2013. Another MNA study activity (suggested by the EPA during their review of the February 14, 2013 memorandum) was modeling chromium attenuation in the aquifer as a tool to assist in the prediction of MNA performance after completing CPS injections.

[1] The fourth Tier is the MNA performance monitoring plan, which will be submitted under separate cover.

This memorandum summarizes the results of computer modeling that was performed to further assess the efficacy of MNA after completing the summer 2013 injections. This memorandum presents the:

- Executive Summary
- Basis of the Model
- Conservative Model Assumptions
- Model Approach and Rationale
- Model Results
- Recommendations

EXECUTIVE SUMMARY

Consistent with regulatory requests, modeling was performed using EPA's BIOSCREEN Model (EPA 1996; EPA 1997) to simulate advective-reactive transport and natural attenuation of dissolved chromium in groundwater via sorption and chemical reduction/precipitation. The SMC MNA Model input included site-specific hydrogeologic parameters, pre-injection source characteristics (i.e., source dimensions, mass and concentration), and measured attenuation rate constants. Certain parameters were adjusted (within the range of measured site-specific values) to calibrate the model. The calibrated model was then used to predict the behavior of chromium in the aquifer after completing the CPS injection program during the summer of 2013.

The SMC MNA Model incorporates many conservative assumptions to enhance its reliability as a predictive tool in evaluating the efficacy of MNA.

The SMC MNA Model concludes that if no active remediation (pumping or injections) is performed after the 2013 injections, **MNA will successfully maintain containment of the chromium plume and will provide for on-going reduction of chromium concentrations in the plume**. More specifically, if no pumping or additional injections are performed after the summer of 2013, the chromium cleanup target will be maintained at the Farm Parcel.

In summary, the SMC MNA Model predicts that the Site will be suitably protected by MNA.

Monitoring is a fundamental and essential part of any MNA program. TRC is submitting an MNA Performance Monitoring Plan under separate cover. Additional evaluation, if necessary, may include additional runs of the SMC MNA Model.

MODEL BASIS

EPA widely recognizes the role of computer modeling for demonstrating the suitability of MNA for mitigating inorganic contaminants in groundwater. EPA identifies reactive transport models as one tool that can be used to evaluate MNA. EPA guidance states that a model should reasonably replicate site-specific groundwater flow conditions and account for processes affecting the fate and transport of the contaminant of interest in the groundwater system to provide meaningful results.

The site-specific groundwater flow and fate and transport processes that provide the foundation for the SMC MNA Model are described in a Conceptual Site Model (CSM), presented in **Attachment 1**. Key elements of the CSM are as follows:

- The Site aquifer is comprised of Cohansey Sand up to approximately 120 feet thick and is bounded below by the silt/clay Kirkwood Formation.
- The average saturated thickness of the aquifer is approximately 120 feet. For purposes of data management, the Site aquifer is differentiated into the upper and lower zones with the upper zone forming the upper 75 feet of the aquifer and the deeper zone occurring at depths below 75 feet.
- The body of monitoring evidence has demonstrated that there is little vertical gradient throughout the Site aquifer (i.e., groundwater flow is predominantly horizontal). Therefore, each zone of the aquifer can be modeled as an independent unit for the purpose of evaluating chromium fate and transport.
- As described in the February 14, 2013 memorandum, dissolved chromium is being attenuated within the aquifer through iron-mediated processes including chemical reduction/precipitation and sorption. Attenuation rates are somewhat higher in the lower zone due to greater iron contents of soils in this zone.

These conditions are consistent with the fundamental assumptions of the BIOSCREEN Model and thus make the model useful as a predictive tool for MNA. Since groundwater flow and chromium transport is predominantly horizontal, the upper zone and the lower zone were modeled separately to account for differences in aquifer properties, source characteristics and attenuation rates unique to each zone. Since regulatory criteria are assigned to total chromium, it has been used as the simulated contaminant[2].

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[2] The total chromium plume has historically exhibited similar trends to that of hexavalent chromium, which is the reactive and mobile species with the bulk soluble mass and the target of remediation.

CONSERVATIVE ASSUMPTIONS

The SMC MNA Model incorporates a number of conservative assumptions to enhance its reliability as a predictive tool in evaluating the efficacy of MNA. These assumptions include:

- Conservative assumption #1: The mass of the chromium plume at the Farm Parcel Treatment Area at the time of the October 2012 sampling will be reduced by 50 percent only, following CPS injection in 2013. This assumption is conservative because the summer 2013 injections will be designed to reduce the bulk of the remaining chromium mass.

- Conservative assumption #2: The mass of chromium at the Car Wash will be the same mass detected during October 2012 sampling. Realistically, the mass of the Car Wash will be reduced by planned summer 2013 injections. Nonetheless, these Car Wash mass assumptions provide a conservative starting point.

- Conservative assumption #3: The mass of chromium currently present at the Car Wash property was assumed to be static. However, the mass of the Car Wash will be reduced by planned summer 2013 injections at this property. Consequently, this assumption causes the model to be inherently conservative with respect to evaluating natural attenuation of dissolved chromium in the aquifer. In addition, dissolved chromium in groundwater in the vicinity of the Car Wash is transported through the Farm Parcel Treatment Area. Residual CPS contained in the Farm Parcel Treatment Area provides a reactive zone that removes chromium from groundwater as it is transported from the Car Wash Area.

- Conservative assumption #4: The starting chromium mass was selected from the set of wells with the highest chromium concentrations.

- Conservative assumption #5: The chromium concentrations at the modeled source areas were assumed to be uniform and to be the highest detected concentrations. This assumption is conservative because concentrations vary vertically and are often less than the assumed highest concentrations.

- Conservative assumption #6: The chromium mass of the entire plume upgradient and downgradient of the model source areas were assigned to relatively thin strips with uniform concentrations throughout the source thickness. This assumption is conservative because it concentrates the chromium mass at a small source area, which induces very steep concentration gradients and highly conservative transport scenarios downgradient of the source area. Furthermore, this conservative scenario intentionally disregards the attenuation and retarded transport of chromium from areas upgradient of model source area and

underestimates the travel time from areas upgradient of modeled source area locations to downgradient sentinel (compliance) points.

- Conservative assumption #7: The model disregards the attenuation and remedial effects of the residual CPS mass post 2011-2013 injections, which will serve as a long-term reactive zone for further decreasing the chromium mass within the aquifer as it is distributed between injection locations.

- Conservative assumption #8: Key attenuation parameters (i.e., retardation and reduction/precipitation rates) used as model input parameters represent the lower ranges of estimated or measured values. This assumption is conservative because it potentially results in overestimating the chromium concentrations at and underestimating the travel time to sentinel locations.

- Conservative assumption #9: Target/trigger concentrations at sentinel locations along the downgradient edge of the plume were less than the remediation goal of 100 µg/l. This assumption incorporates an additional factor-of-safety into the model.

It should also be noted that the SMC MNA Model assumes that there is no pumping and therefore, there is no active removal of dissolved mass except through natural attenuation. While pumping has been temporarily deactivated, additional CPS injections could be performed or pumping could resume in a targeted area should it be deemed necessary and appropriate.

MODELING APPROACH AND RATIONALE

Groundwater modeling was performed in general accordance with American Society for Testing and Materials standards (ASTM 2006). BIOSCREEN is an EPA-endorsed computer model developed to simulate advective-reactive transport and natural attenuation of dissolved contaminants in groundwater. The model accounts for one-dimensional advection, three-dimensional dispersion, and linear sorption. The model can also account for physical and chemical processes (e.g., chemical reduction and precipitation) responsible for attenuation of inorganic contaminants including chromium that exhibit first-order decay behavior through the use of an attenuation rate constant. The analytical equations and assumptions used in the model to simulate chromium transport and attenuation are presented in **Attachment 2**.

The modeling involved the following four steps:

1. **Setup and Development of Equivalent Hydrogeological Model.** An equivalent hydrogeological model was developed to simulate general hydrogeologic conditions, flow patterns, and concentration ranges and trends at specific locations within each of the upper

and lower plumes (i.e., plumes in the upper and lower zones of the aquifer). The equivalent model consists of one layer with a thickness that is similar to that of the corresponding plume, and an equivalent line-source zone (strip) assigned in the respective area of highest pre-injection chromium concentrations at the Farm Parcel Treatment Area. The equivalent line source-zones for the upper and lower plumes were assigned to transects U7 and L7, respectively, at the Farm Parcel Treatment Area. Each source zone was allocated the bulk chromium mass and average width of the corresponding plume.

Site-specific parameters for the upper and lower aquifer zones required as input for the BIOSCREEN model were compiled from previous studies/investigations to provide an initial set of input data for the model simulations. Sources of these data are identified in the model input summary tables provided in **Attachment 2**.

2. **Model Calibration.** The model was run using the site-specific ranges of key modeling parameters that represent governing transport and attenuation processes to reproduce observed chromium concentrations at monitoring well locations not significantly affected by groundwater extraction. A sensitivity analysis approach was followed for model calibration whereby a range for each key parameter was used in the simulations to reflect spatial heterogeneity and temporal variability of hydrogeologic and geochemical conditions within the aquifer. The combinations of input parameters used to achieve calibration are presented in **Attachment 2**.

   As documented by TRC (2013), the two key attenuation processes for chromium within the aquifer are sorption and chemical reduction/precipitation[3] (chemical decay). Since both processes are iron-based, it is difficult to differentiate between them. Furthermore, both processes can and often do occur concurrently. For this reason and to be conservative, sorption and chemical reduction/precipitation were simulated as combined attenuation processes using the range of bulk attenuation factors measured in the upper and lower plumes and documented in the February 14, 2013 memorandum submitted to EPA. This approach was reflected in BIOSCREEN by simulating no retardation transport (i.e., retardation factor at or close to 1), and assigning a bulk attenuation rate constant to account for the overall attenuation of chromium by both processes.

   Pre-injection concentrations of chromium detected in the following wells downgradient of the simulated line source at the U7/L7 transect during April 2012 were used as calibration targets for the model:

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[3] For purposes of this memorandum, chemical reduction/precipitation is conceptually described as chemical decay.

- Upper Plume: U7-A, U7-B, U7-D, U8-B, U8-C and U8-E;
- Lower Aquifer: L7-C1, L7-E1/E2, LPW-8, LPW-9, L8-B1/B2, and SC-5D.[4]

The locations of these monitoring wells are shown on **Figures 1** and **2**. Model calibration simulations for both plumes are provided in **Attachment 3**.

3. **Predictive MNA Modeling.** The SMC MNA Model was used to simulate concentrations at selected sentinel well locations after completing the 2013 CPS injections at the Farm Parcel Treatment Area in order to determine whether the plume is effectively contained by MNA. For these model runs, equivalent line sources of chromium were assigned at the northeastern side of the Farm Parcel along the U8 transect in the upper aquifer and the L8 transect in the lower aquifer. This transect was selected as the equivalent source location for these simulations because it lies along the upgradient side of the Farm Parcel and is upgradient of the Farm Parcel extraction well and downgradient of the area with the overall highest chromium concentrations.

   The simulations were performed using the range of calibrated input parameters provided in **Attachment 2** to predict chromium concentrations at sentinel wells (SC-1S/D, SC-24S/D, and SC-31D) at the downgradient and cross gradient boundaries of the Farm Parcel. To establish mass/concentration reduction targets for the summer 2013 CPS injections and simulate post-summer 2013 conditions, equivalent source concentrations (and mass) used in the calibrated model were incrementally reduced and were modeled in one-year time increments for a 30-year period until simulated concentrations in the sentinel wells for each one-year time step was below the 100 µg/l cleanup goal for chromium. Model simulations yielding the most conservative chromium distribution[5] are provided in **Attachment 4**.

4. **Predictive Modeling to Assess Natural Attenuation of Chromium at Car Wash Area under Non-Pumping Conditions.** Simulations were performed using calibrated input parameters to predict maximum chromium concentrations that could potentially migrate from the Car Wash property to monitoring wells located on the Farm Parcel with the Car Wash extraction wells shut off. Concentrations predicted at monitoring wells on the Farm Parcel

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[4] Locations L7-E1/E2, LPW-8/LPW-9, and L8-B1/B2 represent locations with two wells screened at different intervals in the lower aquifer. For calibration, chromium concentrations from each well-couplet were averaged and compared to predicted concentrations.

[5] These simulations are for the one-year time step that represent maximum predicted chromium concentrations at the sentinel wells during the 30-year simulation period.

were combined and superimposed with predicted concentrations from the previous step to evaluate if the aquifer had the capacity to attenuate existing chromium concentrations at the Car Wash Area without treatment. For these simulations, a transect bisecting the Car Wash extraction wells was simulated as an equivalent line-source using total chromium concentrations detected in wells at the Car Wash Area during April 2013. The April 2013 data set was selected since total chromium concentrations during this monitoring event reflect the maximum chromium concentrations following CPS injections at the facility. This introduces additional conservatism into the model. The mass assigned to equivalent sources was conservatively assumed to be 25% of the total chromium mass in the entire upgradient Facility plumes prior to CPS injections. Model simulations that represent maximum chromium concentration contributions from the Car Wash Area to the Farm Parcel sentinel wells over a 30-year simulation period at one-year time steps are provided in **Attachment 5**.

MODELING RESULTS

Calibration

A statistical analysis was performed to evaluate the accuracy of the model and the goodness of the fit between the predicted and observed total chromium concentrations for each set of calibration parameters. Results of this analysis are presented in **Attachment 6**.

The statistical analysis indicates that the calibrated model predicts the distribution of average chromium concentrations in the upper and lower plumes with reasonable accuracy with correlation factors $(R^2)^6$ of 0.97 for the upper plume and 0.90 for the lower plume.

Predicted Concentrations at Farm Parcel Sentinel Wells in Response to MNA Post-CPS Injections

Table 1 summarizes the results of modeling simulations performed to predict average chromium concentration targets at the Farm Parcel Treatment Area for the upper and lower plumes for successful implementation of MNA. The results presented in **Table 1** consider maximum predicted concentrations of chromium that could potentially be transported from the Car Wash Area to the sentinel wells at the Farm Parcel with no pumping at the Car Wash. **Figures 1** and **2** show the predicted extent of chromium concentrations above groundwater cleanup criterion based upon results of the combined Farm Parcel and Car Wash model simulations. These figures demonstrate that:

1. Natural attenuation is capable of reducing existing chromium concentrations in groundwater at the Car Wash Area below the groundwater cleanup criteria before reaching the Farm Parcel.

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[6] $R^2 = 1$ represents an exact match between predicted and observed concentrations

2. Natural attenuation should effectively mitigate average post-CPS injection (residual) chromium concentrations of approximately 750 µg/l in the upper aquifer, and 1,250 µg/l in the lower aquifer at the Farm Parcel Treatment Area and maintain concentrations below regulatory criteria in sentinel wells at the boundaries of the Farm Parcel. Model sensitivity evaluations indicate that localized temporal detections of chromium as high as 1,000 µg/l in the upper aquifer and 2,700 µg/l in the lower aquifer may be tolerated at the Farm Parcel Treatment Area and may not result in exceedances to the remediation goal of 100 µg/l at the compliance boundary.

In summary, the SMC MNA Model indicates that following CPS injections, MNA will effectively provide a stable plume remedy, protective of downgradient locations. The results demonstrate that upon attaining satisfactory chromium concentration goals at the Farm Parcel (average concentrations of 750 µg/l in the upper zone and 1,250 µg/L in the lower zone) per the model's conservative predictions, concentrations of chromium at compliance sentinel wells[7] will be substantially less than the cleanup goal.

RECOMMENDATIONS

The SMC MNA Model predicts that the Site will be suitably protected by MNA. Monitoring is a fundamental and essential part of any MNA program. It is necessary to implement the MNA Performance Monitoring Plan diligently, so that helpful post-injection data is obtained. TRC will be preparing and submitting an MNA Performance Monitoring Plan under a separate cover.

References

ASTM Standard D5880 – 95 (2006). "Standard Guide for Subsurface Flow and Transport Modeling", American Society of Testing & Materials (ASTM) International, West Conshohocken, PA.

Dan Raviv Associates, 1990. Summary of Geohydrologic Information Collected Since January 1988, Shield Alloy Metallurgical Corporation, Newfield, New Jersey. April 1990.

Newell, C.J, Rifai, H.S., Wilson, T.J., Connor, J.A.,Aziz, J.A., and Suarez M. P., November 2002. "Calculations and Use of First-Order Rate Constants for Monitored Natural Attenuation Studies". USEPA Groundwater Issue (EPA/540/S-2/500).

TRC Environmental Corporation 2013. "EPA Procedural Assessment of MNA of Chromium at the SMC Site". Memorandum to EPA. February 14, 2013.

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[7] Farm Parcel wells SC-1S/D, SC-5S/D, SC-24S/D, and SC-31D

USEPA 1996, BIOSCREEN, Natural Attenuation Decision Support System, User's Manual, Version 1.3 (EPA 600/R-96/087), Cincinnati, Ohio.

USEPA 1997, BIOSCREEN, Natural Attenuation Decision Support System, User's Manual, Version 1.4 Revisions, Cincinnati, Ohio.

USEPA, 2007. *Monitored Natural Attenuation (MNA) of Inorganic Contaminants in Ground Water.* Volume 1 of 2. (EPA600/R-07/139), Ada Oklahoma.

Walton, W.C., 1991. Principles of Groundwater Engineering. Lewis Publishers, Boca Raton, FL.

Table 1
Chromium Attenuation Modeling Results
Predicted Concentrations of Total Chromium
In Groundwater Downgradient of Facility Using Bulk Attenuation Factor To Simulate Attenuation Processes
Shieldalloy Site
Newfields, New Jersey

RESULTS FOR UPPER PLUME

Monitoring Well Location	Source of Base Input Parameters[1]:		Maximum Predicted Concentration Over 30 Year Simulation Period (mg/L)											
			Calibration Run 4a				Calibration Run 4a r1				Calibration Run 5a r1			
	Model Scenario:		0.5 mg/L Target Source Concentration, ($C_{0.5}$)	0.75 mg/L Target Source Concentration ($C_{0.75}$)	Existing Car Wash Conc. ($C_{car\ wash}$)	Maximum Predicted Conc. At Farm Parcel Max ($C_{0.5}$ and $C_{0.75}$) + $C_{car\ wash}$	0.5 mg/L Target Source Concentration, ($C_{0.5}$)	0.75 mg/L Target Source Concentration ($C_{0.75}$)	Existing Car Wash Conc. ($C_{car\ wash}$)	Maximum Predicted Conc. At Farm Parcel Max ($C_{0.5}$ and $C_{0.75}$) + $C_{car\ wash}$	0.5 mg/L Target Source Concentration, ($C_{0.5}$)	0.75 mg/L Target Source Concentration ($C_{0.75}$)	Existing Car Wash Conc. ($C_{car\ wash}$)	Maximum Predicted Conc. At Farm Parcel Max ($C_{0.5}$ and $C_{0.75}$) + $C_{car\ wash}$
	Coordinates Relative to Farm Parcel Line Source (feet):													
	X	Y												
SC-1S	803	266	0.013	0.016	0	0.016	0.029	0.038	0.002	0.04	0.011	0.014	0	0.014
SC-3S	453	133	0.062	0.081	0.001	0.082	0.1	0.133	0.008	0.141	0.055	0.073	0.001	0.074
SC-5S	86	167	0.066	0.066	0	0.066	0.072	0.073	0	0.073	0.068	0.07	0	0.07
SC-24S	762	333	0	0	0	<0.010	0	0	0	<0.010	0	0	0	<0.010
IW-3	185	300	0	0	0.004	<0.010	0	0	0.014	0.014	0	0	0.004	≤0.010

RESULTS FOR LOWER PLUME

Monitoring Well Location	Source of Base Input Parameters[1]:		Maximum Predicted Concentration Over 30 Year Simulation Period (mg/L)											
			Calibration Run 5				Calibration Run 6				Calibration Run 7			
	Model Scenario:		1.0 mg/L Target Source Concentration, ($C_{1.0}$)	1.25 mg/L Target Source Concentration ($C_{1.25}$)	Existing Car Wash Conc. ($C_{car\ wash}$)	Maximum Predicted Conc. At Farm Parcel Max ($C_{1.0}$ and $C_{1.25}$) + $C_{car\ wash}$	1.0 mg/L Target Source Concentration, ($C_{1.0}$)	1.25 mg/L Target Source Concentration ($C_{1.25}$)	Existing Car Wash Conc. ($C_{car\ wash}$)	Maximum Predicted Conc. At Farm Parcel Max ($C_{1.0}$ and $C_{1.25}$) + $C_{car\ wash}$	1.0 mg/L Target Source Concentration, ($C_{1.0}$)	1.25 mg/L Target Source Concentration ($C_{1.25}$)	Existing Car Wash Conc. ($C_{car\ wash}$)	Maximum Predicted Conc. At Farm Parcel Max ($C_{1.0}$ and $C_{1.25}$) + $C_{car\ wash}$
	Coordinates Relative to Farm Parcel Line Source (feet):													
	X	Y												
SC-1D	1185	142	0.015	0.018	0.003	0.021	0.017	0.02	0.001	0.021	0.011	0.013	0	0.013
SC-3D	450	200	0.138	0.155	0.03	0.185	0.144	0.163	0.013	0.176	0.121	0.132	0.007	0.139
SC-24D	767	300	0.013	0.013	0.001	0.014	0.014	0.014	0.008	0.022	0.010	0.010	0	0.010
SC-31D	617	467	0	0	0	<0.010	0	0	0	<0.010	0	0	0	<0.010

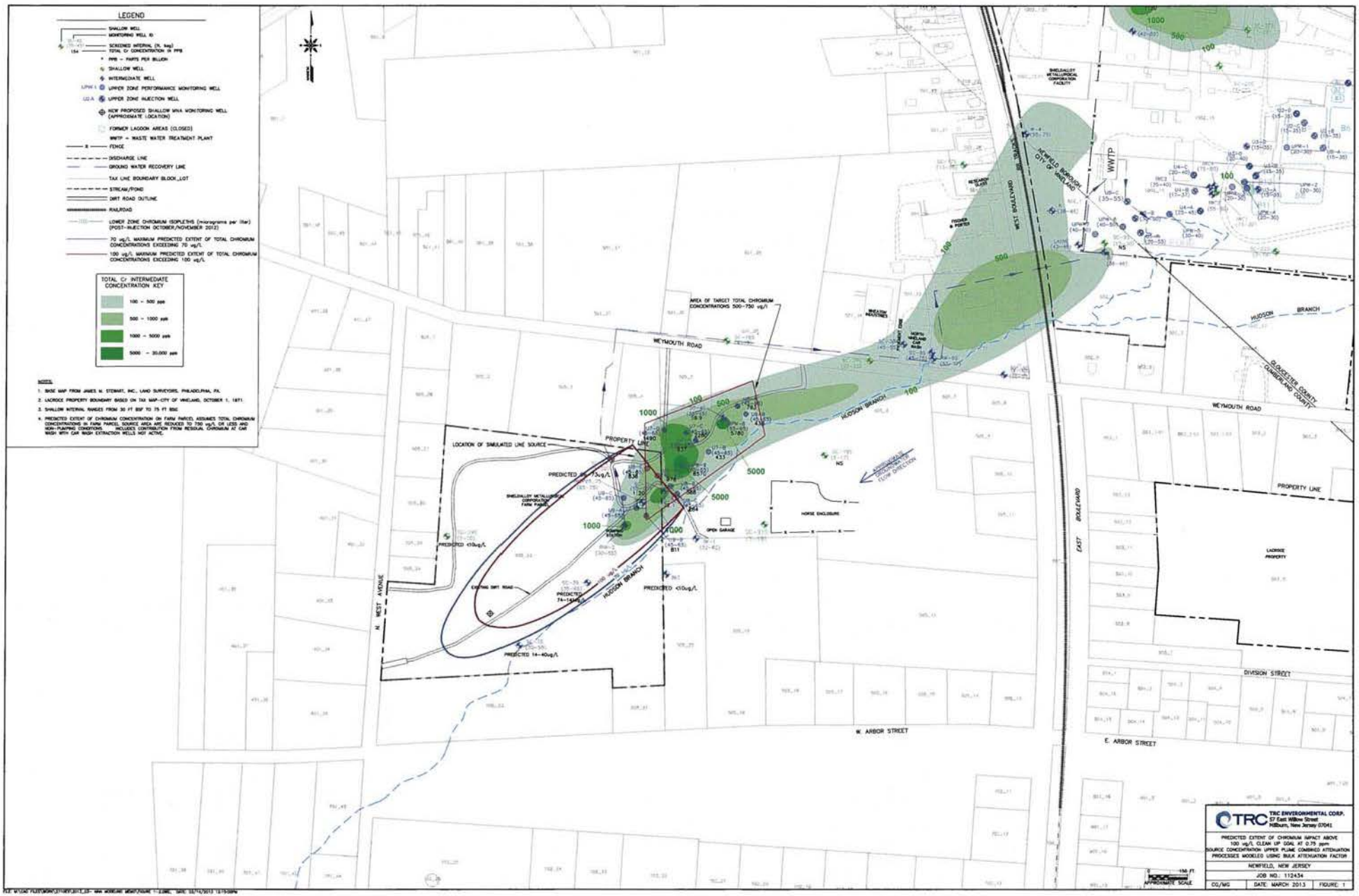
Notes:

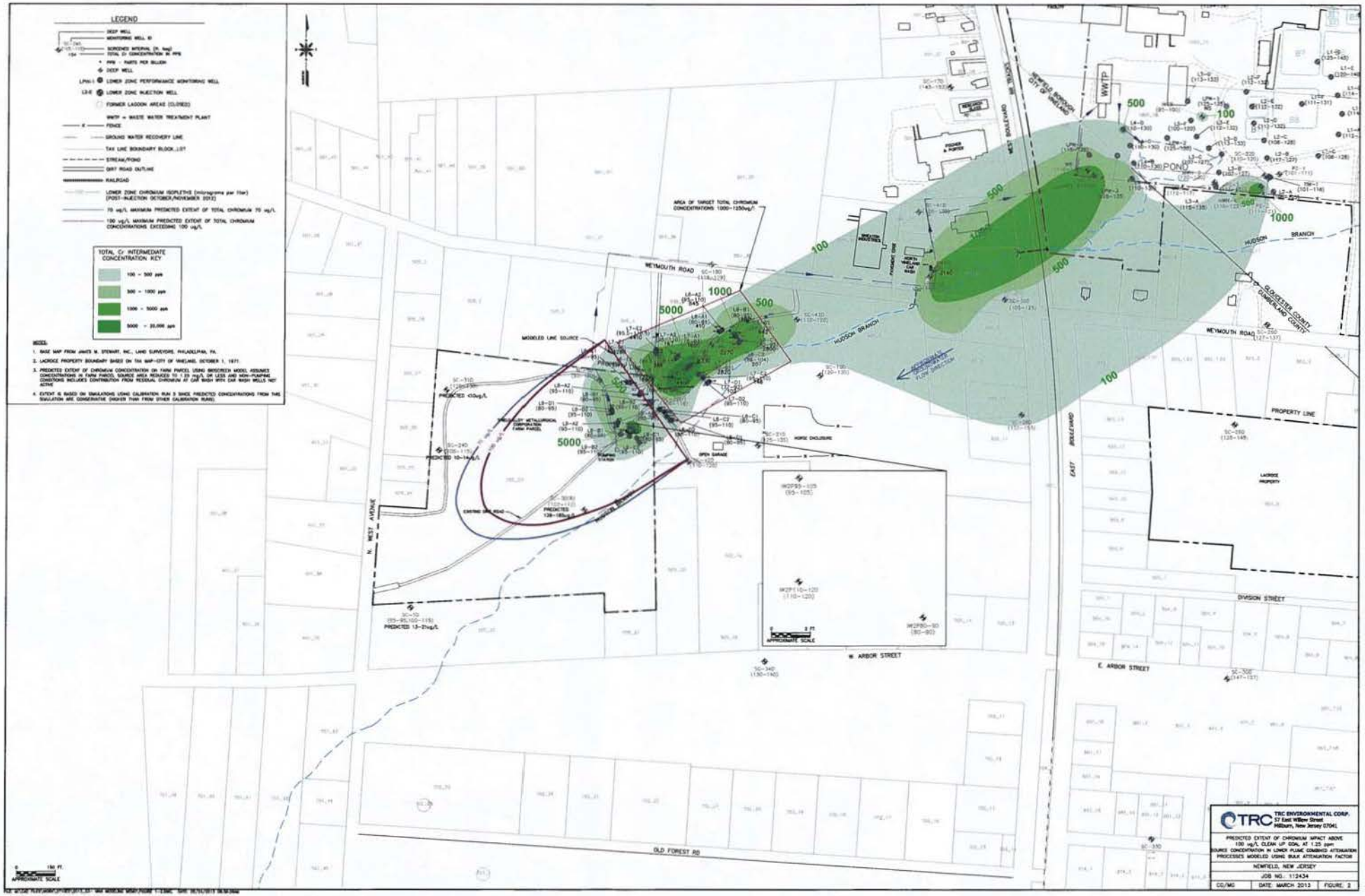
1. [1] - Base parameters include all parameters except source mass and concentrations. For simulations of target concentrations in the Farm Parcel treatment area, the source mass was based upon the assumption that 50 percent of the mass remaining following the first injection would be addressed by subsequent calcium polysulfide injections (roughly 12.5 percent of the original plume mass at the facility used for calibration). For example, the upper end estimate of the mass of chromium source material in the lower plume was conservatively estimated to be approximately 10,000 kilograms. Initial injections were designed to provide sufficient calcium polysulfide to address 75 percent of this mass. Assuming 100 percent efficiency, approximately 2,500 Kg would have remained following the initial treatment. The model simulations are based on the premise that 50 percent of this residual mass will be treated by subsequent calcium polysulfide treatment planned at the site leaving 1,250 Kg of source mass remaining or 1,250 Kg/10.000 Kg (12.5 percent of the orginal mass). Bulk source area concentrations were derived by adjusting the concentrations until predicted concentrations of total chromium above the 70µg/l NJ DEP groundwater criterion and 100 µg/l MCL were entirely within the boundaries of the Farm Parcel.

2. Concentrations of total chromium detected in groundwater at the Car Wash Property (i.e., RW-6S/6D, SC-10S/D, and SC-42D during April 2013) were used to assign source concentrations at the Car Wash to simulate chromium concentrations at the Farm Parcel originating at the Car Wash property under "non-pumping" conditions for the Car Wash Area. The source mass for these simulations was conservatively assumed to be 25 percent of the original source mass of the upper and lower plumes, respectively.

3. <0.010 indicates that the maximum predicted concentration at a particular well location is less than the typical detection limit (i.e., 0.010 mg/l) for total chromium in groundwater for the analytical methods used at Shieldalloy

4. Line source for Upper Plume coincides approximately with UC8 Transect of wells with plume centerline originating near well U8-A. Line source for Lower Plume coincides approximately with L8 Transect of wells with plume centerline originating near well L8-B2.


LEGEND
SHALLOW WELL
MONITORING WELL ID
SCREENED INTERVAL (ft. bgs)
TOTAL Cr CONCENTRATION IN PPB
PPB = PARTS PER BILLION
SHALLOW WELL
INTERMEDIATE WELL
UPPER ZONE PERFORMANCE MONITORING WELL
UPPER ZONE INJECTION WELL
NEW PROPOSED SHALLOW MNA MONITORING WELL (APPROXIMATE LOCATION)
FORMER LAGOON AREAS (CLOSED)
WWTP = WASTE WATER TREATMENT PLANT
FENCE
DISCHARGE LINE
GROUND WATER RECOVERY LINE
TAX LINE BOUNDARY BLOCK_LOT
STREAM/POND
DIRT ROAD OUTLINE
RAILROAD
LOWER ZONE CHROMIUM ISOPLETHS (micrograms per liter) (POST-INJECTION OCTOBER/NOVEMBER 2012)
70 ug/L MAXIMUM PREDICTED EXTENT OF TOTAL CHROMIUM CONCENTRATIONS EXCEEDING 70 ug/L
100 ug/L MAXIMUM PREDICTED EXTENT OF TOTAL CHROMIUM CONCENTRATIONS EXCEEDING 100 ug/L
TOTAL Cr INTERMEDIATE CONCENTRATION KEY
100 - 500 ppb
500 - 1000 ppb
1000 - 5000 ppb
5000 - 20,000 ppb
NOTES:
1. BASE MAP FROM JAMES N. STEWART, INC., LAND SURVEYORS, PHILADELPHIA, PA.
2. LACROCE PROPERTY BOUNDARY BASED ON TAX MAP-CITY OF VINELAND, OCTOBER 1, 1971.
3. SHALLOW INTERVAL RANGES FROM 30 FT BSF TO 75 FT BSC
4. PREDICTED EXTENT OF CHROMIUM CONCENTRATION ON FARM PARCEL ASSUMES TOTAL CHROMIUM CONCENTRATIONS IN FARM PARCEL SOURCE AREA ARE REDUCED TO 750 ug/L OR LESS AND NON-PUMPING CONDITIONS. INCLUDES CONTRIBUTION FROM RESIDUAL CHROMIUM AT CAR WASH WITH CAR WASH EXTRACTION WELLS NOT ACTIVE.
AREA OF TARGET TOTAL CHROMIUM CONCENTRATIONS 500-750 ug/L
WEYMOUTH ROAD
LOCATION OF SIMULATED LINE SOURCE
PROPERTY LINE
PREDICTED 70-74ug/L
PREDICTED <10ug/L
PREDICTED 14-40ug/L
EXISTING DIRT ROAD
HUDSON BRANCH
N. WEST AVENUE
W. ARBOR STREET
E. ARBOR STREET
DIVISION STREET
EAST BOULEVARD
WWTP
NEWFIELD BOROUGH CITY OF VINELAND
SHIELDALLOY METALLURGICAL CORPORATION FACILITY
SHIELDALLOY METALLURGICAL CORPORATION FARM PARCEL
LACROCE PROPERTY
HORSE ENCLOSURE
OPEN GARAGE
GLOUCESTER COUNTY CUMBERLAND COUNTY
APPROXIMATE GROUNDWATER FLOW DIRECTION
TRC ENVIRONMENTAL CORP.
57 East Willow Street
Millburn, New Jersey 07041
PREDICTED EXTENT OF CHROMIUM IMPACT ABOVE 100 ug/L CLEAN UP GOAL AT 0.75 ppm SOURCE CONCENTRATION UPPER PLUME COMBINED ATTENUATION PROCESSES MODELED USING BULK ATTENUATION FACTOR
NEWFIELD, NEW JERSEY
JOB NO.: 112434
CG/MG
DATE: MARCH 2013
FIGURE: 1
150 FT.
APPROXIMATE SCALE


LEGEND
DEEP WELL
MONITORING WELL ID
SCREENED INTERVAL (ft. bgs)
TOTAL Cr CONCENTRATION IN PPB
PPB - PARTS PER BILLION
DEEP WELL
LOWER ZONE PERFORMANCE MONITORING WELL
LOWER ZONE INJECTION WELL
FORMER LAGOON AREAS (CLOSED)
WWTP = WASTE WATER TREATMENT PLANT
FENCE
GROUND WATER RECOVERY LINE
TAX LINE BOUNDARY BLOCK...LOT
STREAM/POND
DIRT ROAD OUTLINE
RAILROAD
LOWER ZONE CHROMIUM ISOPLETHS (micrograms per liter) (POST-INJECTION OCTOBER/NOVEMBER 2012)
70 ug/L MAXIMUM PREDICTED EXTENT OF TOTAL CHROMIUM 70 ug/L
100 ug/L MAXIMUM PREDICTED EXTENT OF TOTAL CHROMIUM CONCENTRATIONS EXCEEDING 100 ug/L
TOTAL Cr INTERMEDIATE CONCENTRATION KEY
100 - 500 ppb
500 - 1000 ppb
1000 - 5000 ppb
5000 - 20,000 ppb
NOTES:
1. BASE MAP FROM JAMES M. STEWART, INC., LAND SURVEYORS, PHILADELPHIA, PA.
2. LACROIX PROPERTY BOUNDARY BASED ON TAX MAP-CITY OF VINELAND, OCTOBER 1, 1977.
3. PREDICTED EXTENT OF CHROMIUM CONCENTRATION ON FARM PARCEL USING BIOSCREEN MODEL ASSUMES CONCENTRATIONS IN FARM PARCEL SOURCE AREA REDUCED TO 1.25 mg/L OR LESS AND NON-PUMPING CONDITIONS INCLUDES CONTRIBUTION FROM RESIDUAL CHROMIUM AT CAR WASH WITH CAR WASH WELLS NOT ACTIVE
4. EXTENT IS BASED ON SIMULATIONS USING CALIBRATION RUN 5 SHOCK PREDICTED CONCENTRATIONS FROM THIS SIMULATION ARE CONSERVATIVE (HIGHER THAN FROM OTHER CALIBRATION RUNS).
AREA OF TARGET TOTAL CHROMIUM CONCENTRATIONS 1000-1250ug/l
MODELED LINE SOURCE
PREDICTED <50ug/L
PREDICTED 10-14ug/L
PREDICTED 13-21ug/L
PREDICTES 120-180ug/L
WEYMOUTH ROAD
HUDSON BRANCH
WWTP
POND
N. WEST AVENUE
WEST BOULEVARD
EAST BOULEVARD
W. ARBOR STREET
E. ARBOR STREET
DIVISION STREET
OLD FOREST RD
PROPERTY LINE
LACROIX PROPERTY
GLOUCESTER COUNTY
CUMBERLAND COUNTY
APPROXIMATE SCALE
TRC ENVIRONMENTAL CORP.
57 East Willow Street
Millburn, New Jersey 07041
PREDICTED EXTENT OF CHROMIUM IMPACT ABOVE 100 ug/L CLEAN UP GOAL AT 1.25 ppm SOURCE CONCENTRATION IN LOWER PLUME COMBINED ATTENUATION PROCESSES MODELED USING BULK ATTENUATION FACTOR
NEWFIELD, NEW JERSEY
JOB NO.: 112434
CC/MG
DATE: MARCH 2013
FIGURE 2

ATTACHMENT 1
CONCEPTUAL SITE MODEL

ATTACHMENT 1
CONCEPTUAL SITE MODEL

A. Stratigraphy

The Site is underlain by the Cohansey Formation, which in the area between the Facility and Farm Parcel consists of approximately 125 feet of sandy deposits. The Cohansey Sand is underlain by a unit of low permeability gray clay that is part of the Kirkwood Formation, which is a confining unit that limits the downward movement of groundwater from the Cohansey Sands to deeper aquifers.

At certain depths, these sands contain appreciable amounts of gravel and/or clay. In the area between the Facility and Farm Parcel, the Cohansey Formation exhibits the following stratigraphy from the ground surface, downward.

- Approximately 20 feet of medium to coarse sand with minor amounts of gravel underlain by approximately 40 feet of fine to medium sand and approximately 15 feet of coarser sand with gravel totaling approximately 75 feet. These soils are referred to as the "upper" zone of the aquifer; and

- Approximately 40 feet of sand (with appreciable clay content) underlain by approximately 10 feet of predominantly medium sand. These sands comprise the lower (or deep) zone of the aquifer.

This stratigraphy is shown on geologic cross-section A-A', which extends along the axis of the plume between the Facility and through the Farm Parcel (**Figure A-1**).

B. Groundwater Occurrence and Flow

Groundwater in the Cohansey Sands is unconfined and is generally present at depths ranging from approximately 3 to more than 10 feet below ground surface (bgs) in the area downgradient of the Facility, depending on the time of year and proximity to the Hudson Branch. Groundwater in the upper and lower zones of the aquifer flows horizontally in a southwesterly direction from the Facility towards the Farm Parcel as shown on **Figures A-2** and **A-3**. Until recently, some of this groundwater was extracted by two recovery wells (RW-6S/D) located at the Car Wash Property and treated at a treatment system located at the Shieldalloy facility. These two wells have been temporarily deactivated to evaluate chromium concentration trends under "non-pumping" conditions. Recovery wells at the Facility (i.e., the Layne Well and Well and W-9) and Farm Parcel (i.e., well RIW-2) are not active at this time due to the recent injection of calcium polysulfide (CPS) in the area of these wells to remove hexavalent chromium from groundwater in-situ.

Ambient horizontal hydraulic gradients approximating non-pumping conditions have been estimated using groundwater equipotential contours developed from water level data collected during 2012 at monitoring locations outside of the area of influence of the extraction wells south of the chromium plume. The hydraulic gradient in the upper zone of the aquifer between wells SC-38I and SC-4S and wells SC-3S and SC-1S was calculated to range from approximately 0.0017 to 0.0027. In the lower zone of the aquifer, the horizontal hydraulic gradient was calculated to be approximately 0.0017 based upon differences in water levels measured in wells SC-28D, SC-21D and SC-1D.

Vertical hydraulic gradients downgradient of the Facility are generally small, typically less than 0.005, based upon water level data obtained from the following well couplets during the period between October 2011 and May 2012: SC-3S/D, SC-4S/D, SC-10S/D, SC-18S/D, SC-19S/D, and SC-21S/D. The small vertical hydraulic gradients indicate that in the absence of pumping influences, groundwater flow in the Cohansey Sands downgradient of the Facility is nearly horizontal as shown on **Figure A-1**.

C. Hydraulic Properties of the Aquifer

The hydraulic conductivity of the upper zone is estimated (Raviv Associates, 1990) to range between 250 feet per day (ft/day) to 706 ft/day using the transmissivities calculated by Raviv Associates and saturated thicknesses measured at wells IW-1, IW-2, and SC-3S. Similarly, the hydraulic conductivity of the lower zone of the aquifer was estimated to range between 64 ft/day to 137 ft/day based upon calculated transmissivities and inferred saturated thickness at wells RW-6D and SC-6D (Raviv Associates, 1990).

D. Ground Water Quality

Groundwater has been impacted with chromium from historical wastewater disposal activities at the Shieldalloy Facility. As a result of these activities, a plume of dissolved chromium extends more than 2,000 feet downgradient of the Facility Property. Historically, the highest concentrations of chromium were found in groundwater beneath the Facility and in an area located adjacent to the eastern (hydraulically upgradient) boundary of the Farm Parcel. Chromium concentrations in the upper and lower zones of the aquifer in these two areas historically exceeded 5,000 µg/l and 10,000 µg/l, respectively. The vast majority of chromium mass responsible for these dissolved concentrations is confined to an approximately 10- to 30-foot thick interval in the upper aquifer and a 5- to 25-foot thick zone in the lower aquifer. Larger thicknesses were estimated near the source at the Facility and near Car Wash and the Farm parcel extraction wells.

The original remedy to mitigate chromium in the groundwater was pump and treat. For nearly 20 years, groundwater was recovered from the upper and lower aquifer using five groundwater extraction wells (i.e., W-9, RIW-2, RW-6S, RW-6D, and the Layne Well), treated on-site, and then discharged to the Hudson Branch. Although adequate for containing impacted groundwater, pump and treat is not efficient or cost effective in reducing the high contaminant concentrations and soluble forms of chromium mass in the aquifer to the 100 µg/l cleanup criterion. To address these concerns, the extraction wells at the Facility and Farm Parcel were shut down during 2011 and 2012, respectively, and in-situ chemical reduction using CPS was implemented in the two source areas described previously. As a result of the CPS injections, chromium concentrations in groundwater beneath the vast majority of the Facility have been reduced below the 100 µg/l cleanup criterion and are stable, effectively eliminating further contributions of chromium to the plume from this former source area. Significant reductions in concentrations have also been achieved in the Farm Parcel treatment area. Additional CPS injections are planned to further reduce chromium concentrations in this area. **Figures A-4** through **A-7** present recent concentrations of total and hexavalent chromium (October/November 2012) detected in the upper and lower zones of the aquifer.

The following provides a discussion of chromium concentrations (October 2012) in the upper and lower zones of the aquifer in the Farm Parcel Injection Area and in the area between this source area and the Facility, herein identified as the Car Wash Property.

- Upper Zone – Farm Parcel Injection Area: Concentrations of total chromium in groundwater in the upper aquifer within the injection area (defined as the area between extraction well RIW-2 and performance monitoring well transect U6) following pilot injections ranged from 22.1 µg/l at IW-2 to 6,570 µg/l at UPW-9. With two exceptions, hexavalent chromium concentrations in this area were reduced to less than 40 µg/l. Concentrations of hexavalent chromium at UPW-8 and UPW-9 were 930 µg/l and 13,800 µg/l, respectively. Additional CPS injections are planned in this area in 2013 to further reduce the mass of soluble chromium and concentrations of chromium in groundwater in this area.

- Lower Zone – Farm Parcel Injection Area: Concentrations of total chromium in groundwater within the injection area of the lower aquifer (defined by performance well transects L6 and L9) following pilot scale injections range from 50 µg/l at L9-A1 to 16,800 µg/l at LPW-8. Hexavalent chromium concentrations in this same area range from not detected at several locations up to 12,900 µg/l at LPW-9. Concentrations of chromium in this area will be reduced further as a result of the planned polishing CPS injections in 2013.

- Upper Zone – Car Wash Property: During October 2012, shallow monitoring well SC-6S (screened in the axis of the chromium plume) was sampled at the Car Wash Property. The concentration of total chromium detected in this well was 490 µg/l. The concentration of hexavalent of chromium during October 2012 was anomalously elevated (2,200 µg/l). More recent sampling performed in April 2013 indicates the concentrations of total and hexavalent chromium at the adjacent upper zone recovery well RW-6 are consistent at 503 µg/l and 500 µg/l, respectively.

- Lower Zone - Car Wash Property: Four deep monitoring wells RW-6D, SC-10D, SC-28D, and SC-43D were sampled during October 2012. Concentrations of total chromium in these wells range from 134 µg/l at SC-28D to 2,140 µg/l at Car Wash Extraction Well RW-6D. Hexavalent chromium concentrations in these wells ranged from not detected at SC-10D to 1,500 at well RW-6D. Somewhat higher concentrations of total and hexavalent chromium were detected in RW-6D (4,900 µg/l and 5,400 µg/l) and SC-10D (3,280 µg/l and 2,900 µg/l) during April 2013. These higher concentrations were used to simulate contributions to the Farm Parcel sentinel wells from the Car Wash property.

E. Chromium Fate and Transport

The fate and transport of chromium at the Shieldalloy Site is affected by naturally occurring and anthropogenically induced processes. As previously discussed, CPS has been injected into the upper and lower zones of the aquifer at the Facility and immediately upgradient of the Farm Parcel where the highest concentrations of dissolved chromium have historically been detected. CPS induces geochemical conditions that convert soluble hexavalent chromium to sparingly soluble trivalent chromium hydroxide that precipitates from the groundwater. Previous modeling evaluations performed for the design of CPS injections indicate that CPS will persist in the injection areas for several years and will continue to remove dissolved hexavalent chromium from groundwater that migrates through the injection areas.

Several naturally occurring processes are removing dissolved chromium from groundwater. These processes include:

- Reduction of hexavalent chromium to (and precipitation of) trivalent chromium hydroxide by abundant ferrous iron in the aquifer; and

- Sorption of chromium onto iron oxides, iron complexes, and clay minerals.

The evidence supporting removal of chromium by these processes is described in a memorandum from TRC to EPA dated February 14, 2013. There are no known conditions

within the aquifer that would cause remobilization of chromium that has been sequestered by natural attenuation processes or CPS injections.

DOWN GRADIENT
A

UP GRADIENT
A'

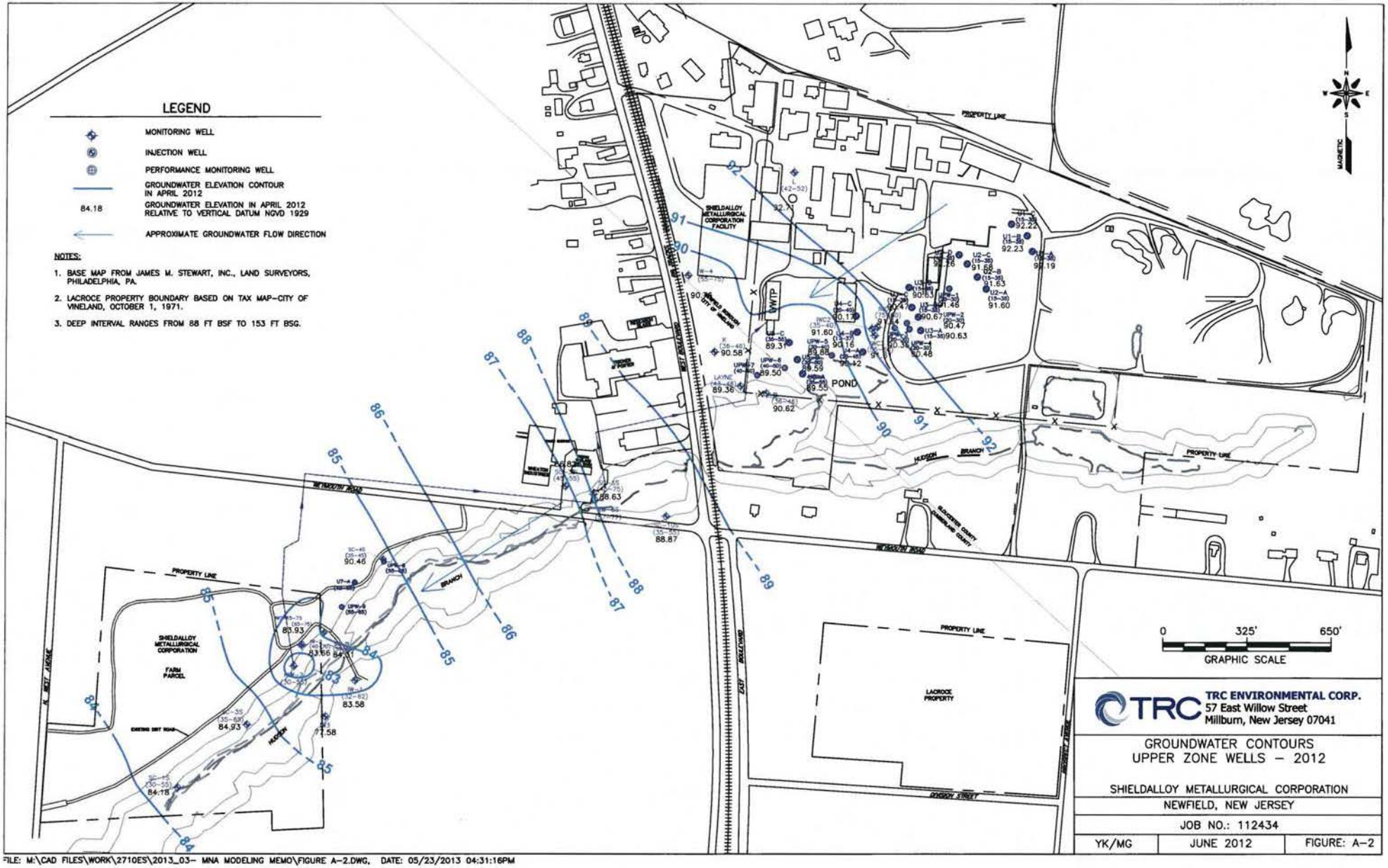
TRC

CONCEPTUAL SITE MODEL
GEOLOGIC CROSS SECTION

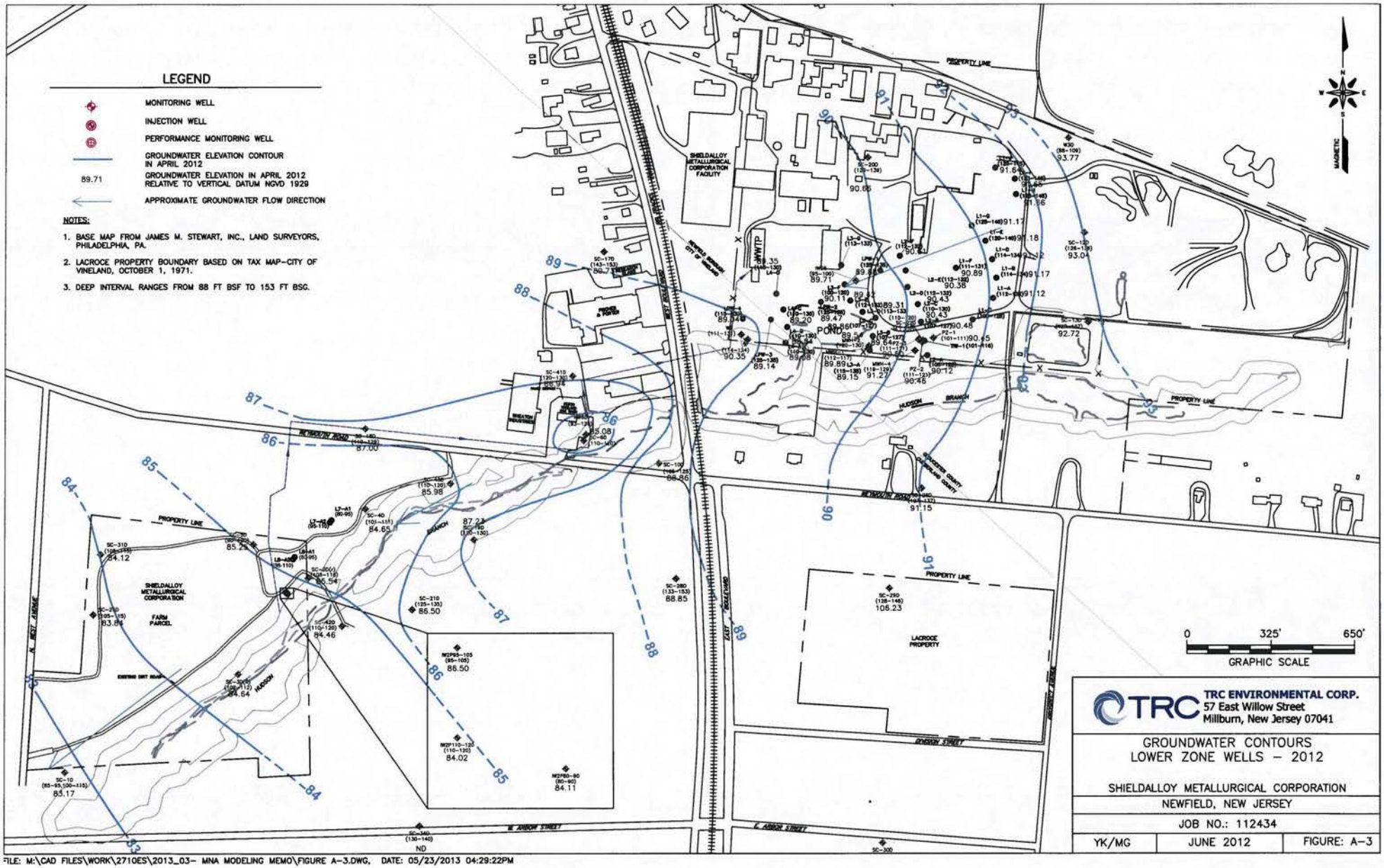
SHIELDALLOY METALLURGICAL CORP. – NEWFIELD, NJ

JOB NO. 2710-113434

DATE: MARCH 2010 | FIGURE: A-1



FILE: M:\CAD FILES\WORK\2710ES\2013_03- MNA MODELING MEMO\FIGURE A-2.DWG, DATE: 05/23/2013 04:31:16PM



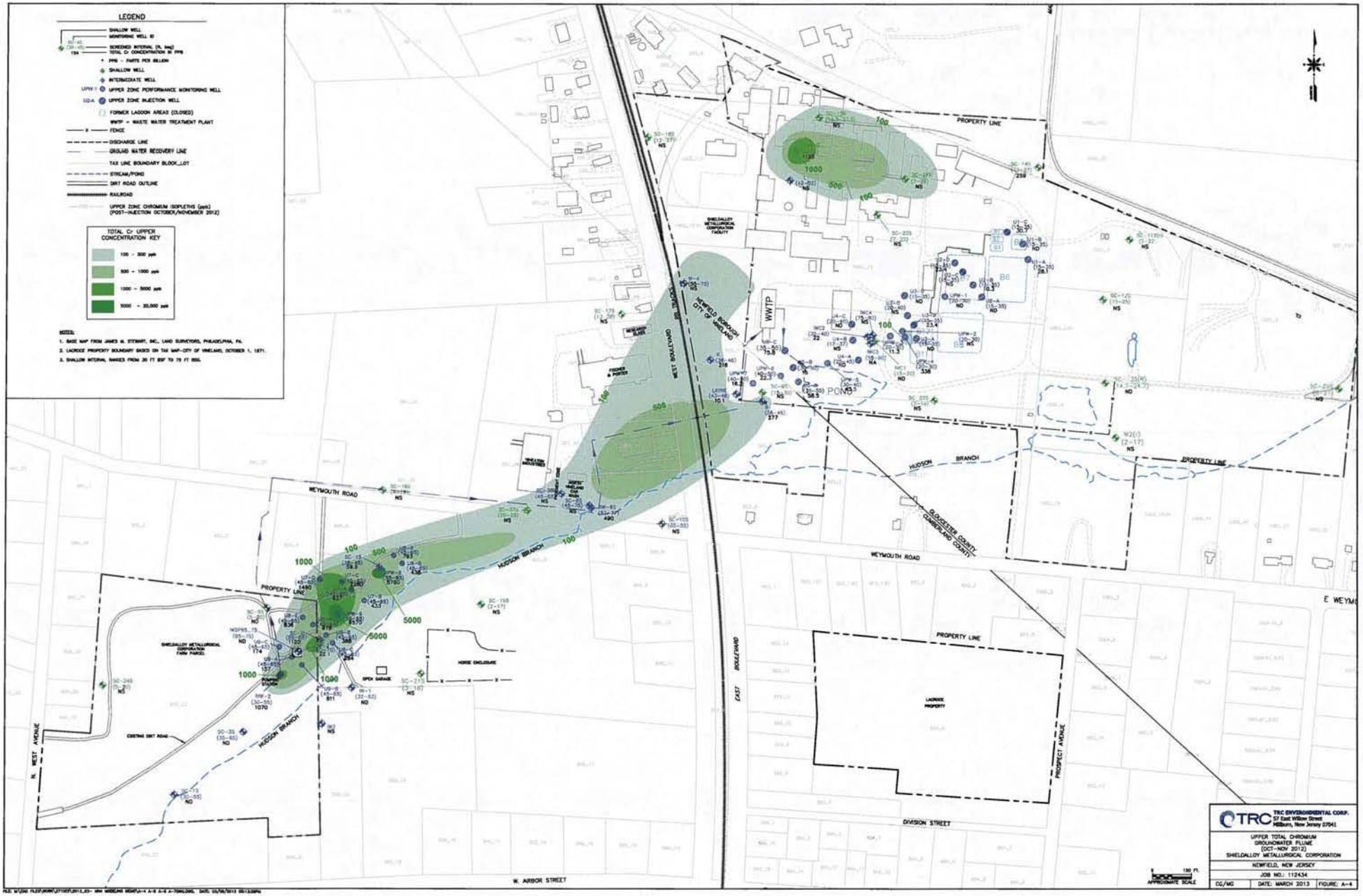
TRC ENVIRONMENTAL CORP.
57 East Willow Street
Millburn, New Jersey 07041

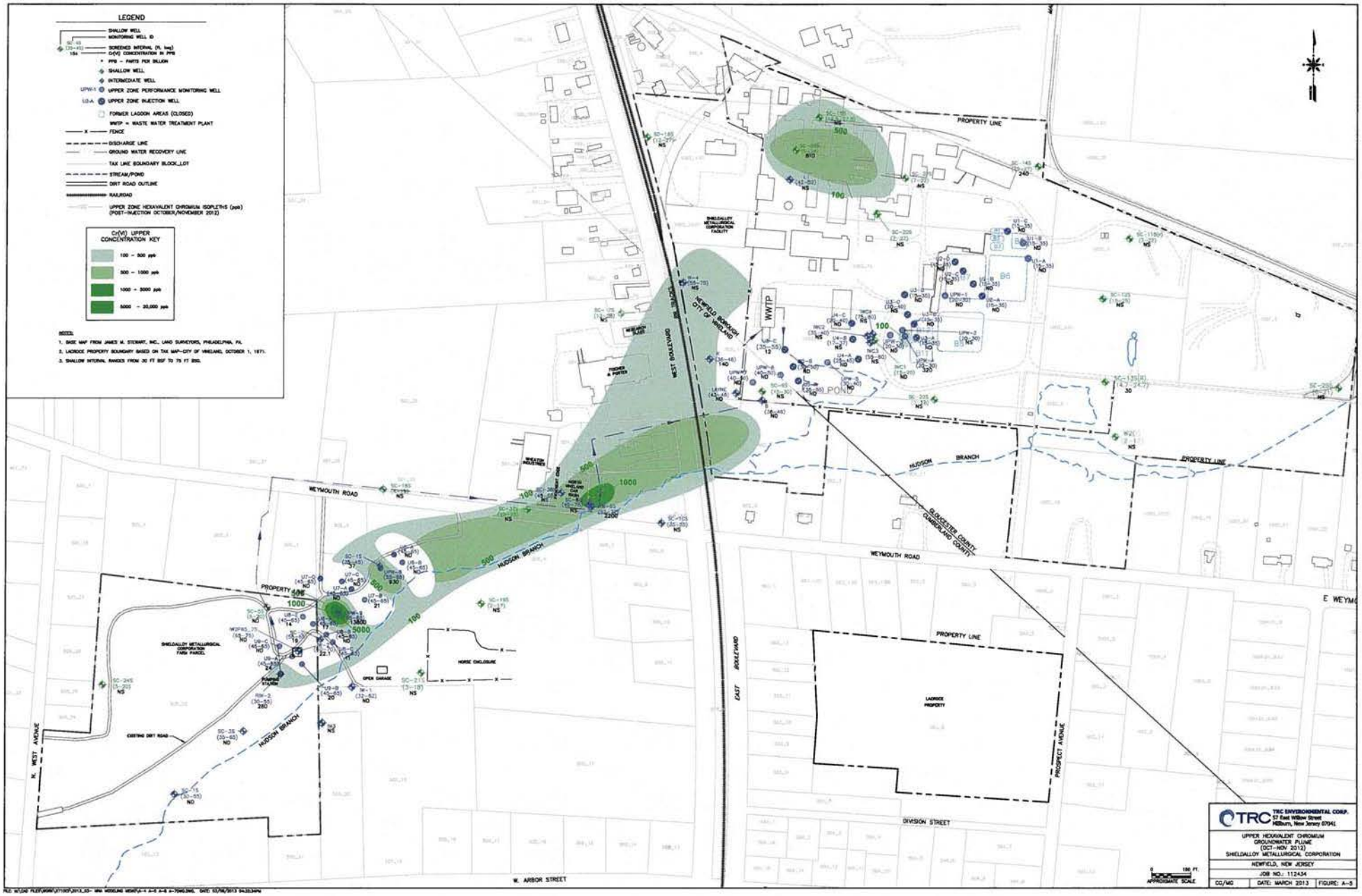
GROUNDWATER CONTOURS
LOWER ZONE WELLS – 2012

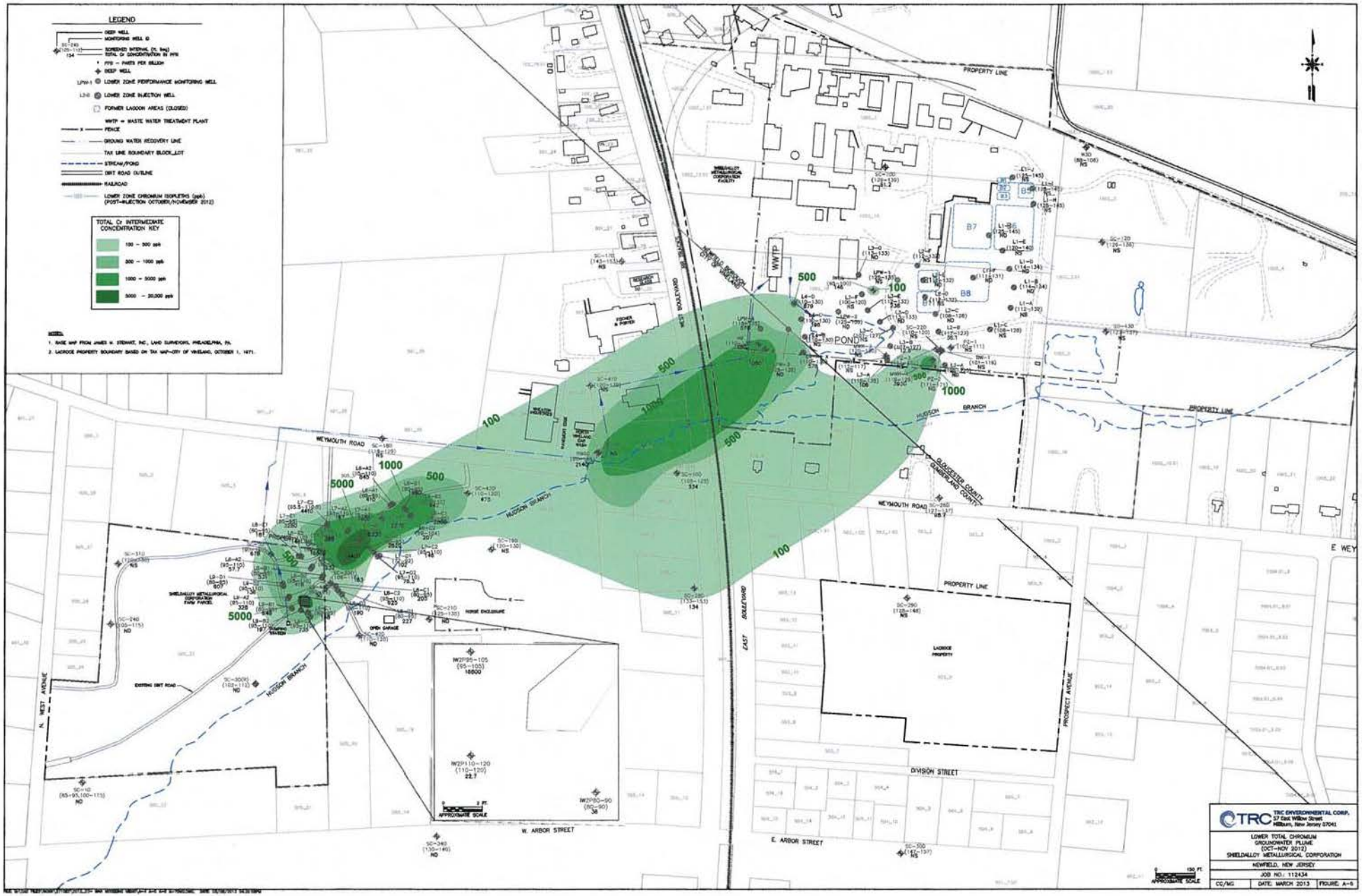
SHIELDALLOY METALLURGICAL CORPORATION
NEWFIELD, NEW JERSEY
JOB NO.: 112434

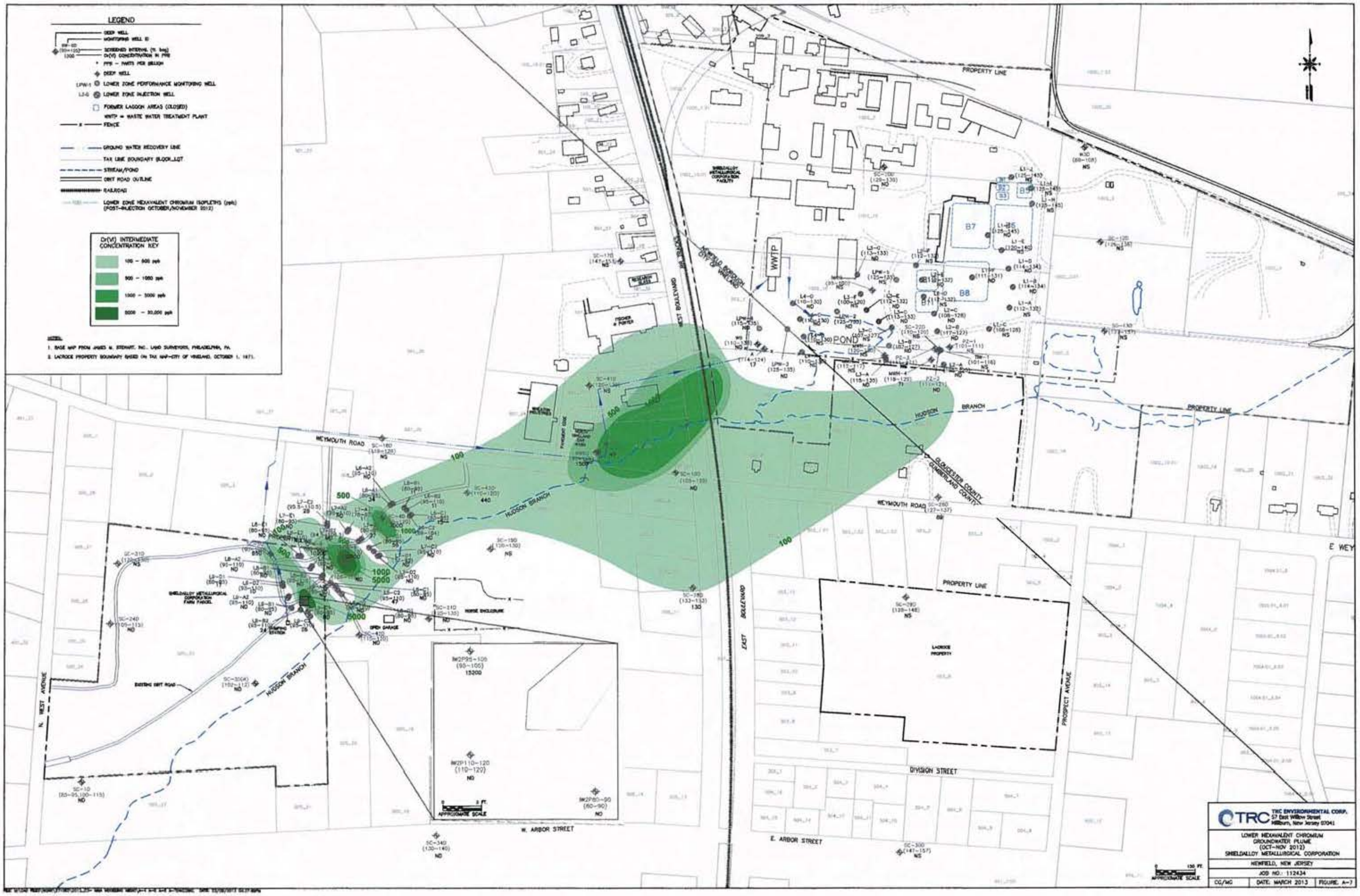
YK/MG	JUNE 2012	FIGURE: A-3

FILE: M:\CAD FILES\WORK\2710ES\2013_03- MNA MODELING MEMO\FIGURE A-3.DWG, DATE: 05/23/2013 04:29:22PM


LEGEND
SHALLOW WELL
MONITORING WELL ID
SCREENED INTERVAL (ft. bmp)
TOTAL Cr CONCENTRATION IN PPB
PPB - PARTS PER BILLION
SHALLOW WELL
INTERMEDIATE WELL
UPW-1 UPPER ZONE PERFORMANCE MONITORING WELL
UZ-A UPPER ZONE INJECTION WELL
FORMER LAGOON AREAS (CLOSED)
WWTP - WASTE WATER TREATMENT PLANT
FENCE
DISCHARGE LINE
(GROUND WATER RECOVERY LINE
TAX LINE BOUNDARY BLOCK_LOT
STREAM/POND
DIRT ROAD OUTLINE
RAILROAD
UPPER ZONE CHROMIUM ISOPLETHS (ppb)
(POST-INJECTION OCTOBER/NOVEMBER 2012)
TOTAL Cr UPPER CONCENTRATION KEY
100 - 500 ppb
500 - 1000 ppb
1000 - 5000 ppb
5000 - 20,000 ppb
NOTES:
1. BASE MAP FROM JAMES M. STEWART, INC., LAND SURVEYORS, PHILADELPHIA, PA.
2. LACROCE PROPERTY BOUNDARY BASED ON TAX MAP-CITY OF VINELAND, OCTOBER 1, 1971.
3. SHALLOW INTERVAL RANGES FROM 20 FT BSF TO 75 FT BSL.
PROPERTY LINE
WEYMOUTH ROAD
HUDSON BRANCH
WEST BOULEVARD
EAST BOULEVARD
N. WEST AVENUE
W. ARBOR STREET
DIVISION STREET
PROSPECT AVENUE
GLOUCESTER COUNTY
CUMBERLAND COUNTY
SHIELDALLOY METALLURGICAL CORPORATION FARM PARCEL
SHIELDALLOY METALLURGICAL CORPORATION FACILITY
LACROCE PROPERTY
WWTP
POND
HORSE ENCLOSURE
OPEN GARAGE
EXISTING DIRT ROAD
IRRIGATION INDUSTRIES
NEWFIELD BOROUGH
CITY OF VINELAND
APPROXIMATE SCALE
TRC ENVIRONMENTAL CORP.
57 East Willow Street
Millburn, New Jersey 07041
UPPER TOTAL CHROMIUM
GROUNDWATER PLUME
(OCT-NOV 2012)
SHIELDALLOY METALLURGICAL CORPORATION
NEWFIELD, NEW JERSEY
JOB NO.: 112434
CG/MG
DATE: MARCH 2013
FIGURE: A-4


LEGEND
SHALLOW WELL
MONITORING WELL ID
SCREENED INTERVAL (ft. bsg)
Cr(VI) CONCENTRATION IN PPB
* PPB = PARTS PER BILLION
SHALLOW WELL
INTERMEDIATE WELL
UPW-1 UPPER ZONE PERFORMANCE MONITORING WELL
UI-A UPPER ZONE INJECTION WELL
FORMER LAGOON AREAS (CLOSED)
WWTP = WASTE WATER TREATMENT PLANT
FENCE
DISCHARGE LINE
GROUND WATER RECOVERY LINE
TAX LINE BOUNDARY BLOCK_LOT
STREAM/POND
DIRT ROAD OUTLINE
RAILROAD
UPPER ZONE HEXAVALENT CHROMIUM ISOPLETHS (ppb) (POST-INJECTION OCTOBER/NOVEMBER 2012)
Cr(VI) UPPER CONCENTRATION KEY
100 - 500 ppb
500 - 1000 ppb
1000 - 5000 ppb
5000 - 20,000 ppb
NOTES:
1. BASE MAP FROM JAMES M. STEWART, INC., LAND SURVEYORS, PHILADELPHIA, PA.
2. LADRIDGE PROPERTY BOUNDARY BASED ON TAX MAP-CITY OF VINELAND, OCTOBER 1, 1971.
3. SHALLOW INTERVAL RANGES FROM 20 FT BSF TO 75 FT BSL.
PROPERTY LINE
WWTP
POND
WEYMOUTH ROAD
HUDSON BRANCH
EAST BOULEVARD
WEST BOULEVARD
PROSPECT AVENUE
DIVISION STREET
W. ARBOR STREET
N. WEST AVENUE
SHELDALLOY METALLURGICAL CORPORATION FARM PARCEL
SHELDALLOY METALLURGICAL CORPORATION FACILITY
LADRIDGE PROPERTY
HORSE ENCLOSURE
OPEN GARAGE
EXISTING DIRT ROAD
GLOUCESTER COUNTY
CUMBERLAND COUNTY
NEWFIELD BOROUGH
CITY OF VINELAND
APPROXIMATE SCALE
0 100 FT.
TRC ENVIRONMENTAL CORP.
57 East Willow Street
Millburn, New Jersey 07041
UPPER HEXAVALENT CHROMIUM GROUNDWATER PLUME (OCT-NOV 2012)
SHELDALLOY METALLURGICAL CORPORATION
NEWFIELD, NEW JERSEY
JOB NO.: 112434
DD/MD
DATE: MARCH 2013
FIGURE: A-5


LEGEND
DEEP WELL
MONITORING WELL ID
SCREENED INTERVAL (ft. bgs)
TOTAL Cr CONCENTRATION IN PPB
ppb = PARTS PER BILLION
DEEP WELL
LOWER ZONE PERFORMANCE MONITORING WELL
LOWER ZONE INJECTION WELL
FORMER LAGOON AREAS (CLOSED)
WWTP = WASTE WATER TREATMENT PLANT
FENCE
GROUND WATER RECOVERY LINE
TAX LINE BOUNDARY BLOCK_LOT
STREAM/POND
DIRT ROAD OUTLINE
RAILROAD
LOWER ZONE CHROMIUM ISOPLETHS (ppb)
(POST-INJECTION OCTOBER/NOVEMBER 2012)
TOTAL Cr INTERMEDIATE CONCENTRATION KEY
100 – 500 ppb
500 – 1000 ppb
1000 – 5000 ppb
5000 – 20,000 ppb
NOTES:
1. BASE MAP FROM JAMES M. STEWART, INC., LAND SURVEYORS, PHILADELPHIA, PA.
2. LACROSE PROPERTY BOUNDARY BASED ON TAX MAP-CITY OF VINELAND, OCTOBER 1, 1971.
PROPERTY LINE
WWTP
POND
HUDSON BRANCH
WEYMOUTH ROAD
DIVISION STREET
W. ARBOR STREET
E. ARBOR STREET
N. WEST AVENUE
EAST BOULEVARD
PROSPECT AVENUE
LACROSE PROPERTY
SHIELDALLOY METALLURGICAL CORPORATION FACILITY
SHIELDALLOY METALLURGICAL CORPORATION FARM PARCEL
FISCHER & PORTER
HORSE ENCLOSURE
OPEN GARAGE
PUMPING STATION
EXISTING DIRT ROAD
GLOUCESTER COUNTY
CUMBERLAND COUNTY
100
500
1000
5000
APPROXIMATE SCALE
TRC ENVIRONMENTAL CORP.
LOWER TOTAL CHROMIUM GROUNDWATER PLUME (OCT-NOV 2012)
SHIELDALLOY METALLURGICAL CORPORATION
NEWFIELD, NEW JERSEY
JOB NO.: 112434
CG/MG
DATE: MARCH 2013
FIGURE: A-6


LEGEND
DEEP WELL
MONITORING WELL ID
SCREENED INTERVAL (ft. bsg)
Cr(VI) CONCENTRATION IN PPB
* PPB - PARTS PER BILLION
DEEP WELL
LPW-1 LOWER ZONE PERFORMANCE MONITORING WELL
LOWER ZONE INJECTION WELL
FORMER LAGOON AREAS (CLOSED)
WWTP = WASTE WATER TREATMENT PLANT
FENCE
GROUND WATER RECOVERY LINE
TAX LINE BOUNDARY BLOCK_LOT
STREAM/POND
DIRT ROAD OUTLINE
RAILROAD
LOWER ZONE HEXAVALENT CHROMIUM ISOPLETHS (ppb) (POST-INJECTION OCTOBER/NOVEMBER 2012)
Cr(VI) INTERMEDIATE CONCENTRATION KEY
100 - 500 ppb
500 - 1000 ppb
1000 - 5000 ppb
5000 - 30,000 ppb
NOTES:
1. BASE MAP FROM JAMES W. STEWART, INC., LAND SURVEYORS, PHILADELPHIA, PA.
2. LACROCE PROPERTY BOUNDARY BASED ON TAX MAP-CITY OF VINELAND, OCTOBER 1, 1971.
PROPERTY LINE
WWTP
POND
B7
B8
HUDSON BRANCH
WEYMOUTH ROAD
EAST BOULEVARD
GLOUCESTER COUNTY
CUMBERLAND COUNTY
E WEY
N. WEST AVENUE
W. ARBOR STREET
E. ARBOR STREET
DIVISION STREET
PROSPECT AVENUE
LACROCE PROPERTY
100
500
1000
5000
APPROXIMATE SCALE
TRC ENVIRONMENTAL CORP.
57 East Willow Street
Millburn, New Jersey 07041
LOWER HEXAVALENT CHROMIUM GROUNDWATER PLUME (OCT-NOV 2012)
SHIELDALLOY METALLURGICAL CORPORATION
NEWFIELD, NEW JERSEY
JOB NO.: 112434
CG/MG
DATE: MARCH 2013
FIGURE A-7

ATTACHMENT 2
DESCRIPTION OF BIOSCREEN MODEL AND INPUT DATA

ATTACHMENT 2
BIOSCREEN MODEL DESCRIPTION AND INPUT PARAMETERS

BIOSCREEN is a model used to simulate remediation of contaminants in groundwater through natural attenuation. The model accounts for major contaminant transport mechanisms including:

- Advection;
- Dispersion;
- Adsorption or retardation;
- Plume decay (degradation) simulated as first-order decay using an attenuation rate constant; and
- Source decay.

Each of these processes including the analytical equations used in the model code is described herein. A range of the model parameters is used in modeling to reflect aquifer heterogeneity and anisotropy. For the modeling simulations performed for the Shieldalloy Site, physical and chemical attenuation parameters (i.e., sorption, chemical reduction, and precipitation) were simulated in combination by maintaining the retardation factor at or near 1.0 and adjusting the bulk attenuation rate constant to mimic the behavior of the plume. Input model parameters used to achieve calibration for the model runs are summarized in **Table A.2.1**.

Advection

Advection simulates contaminant transport at the average groundwater flow velocity and is represented by the average linear seepage velocity (v) based on Darcy's equation:

$$v = \frac{Ki}{n_e}$$

where K is the horizontal hydraulic conductivity, i is the horizontal hydraulic gradient, and n_e is effective porosity. The model assumes homogenous and isotropic conditions within the aquifer and that advective groundwater flow is horizontal. These conditions are reasonable for the site based upon the following considerations:

- The upper and lower aquifers while comprised of slightly different grain size distributions are modeled separately;
- Modeling is projected over a large scale such that minor variations in hydraulic conductivity do not significantly impact the model outcome;

- Vertical hydraulic gradients are small indicating that flow is horizontal within the aquifer and vertical flow is limited.

Dispersion

Dispersion relates to local (micro-scale) changes of the flow velocity due to porosity and changes in the pore diameter. BIOSCREEN accounts for 3-dimensional dispersive transport as follows:

- Longitudinal Dispersivity *(Alpha x or* α_x*)*: along the general groundwater flow direction or main axis of the plume (X-direction), which is represented by the following equation:

$$\text{Alpha x} = 3.28 \cdot 0.83 \cdot \left[\log_{10}\left(\frac{L_p}{3.28}\right)\right]^{2.414}$$

  Where: L_p = Length of the plume in feet, with larger values of L_p resulting in greater spreading of the plume with lower concentrations far-field with increasing α_x.

- Transverse Dispersivity *(Alpha y or* α_y*)*: normal to the main axis of the plume (Y-direction), which is represented by the following equation:

$$\text{Alpha y} = 0.10 \text{ alpha x}$$

- Vertical Dispersion *(Alpha z or* α_z*)*: vertical (Z-direction)

$$\text{Alpha z} = \text{very low (i.e. } 1 \times 10^{-99} \text{ ft)}$$

α_x values for the upper aquifer was estimated to range between approximately 24 to approximately 29 feet and α_y was varied between 2.4 feet to 2.9 feet using the 1/10 rule. For the lower aquifer, α_x set at 24.5 feet and α_y was set between 2.4 feet. The conservative model default value of zero for vertical dispersivity (α_z) was used for all simulations.

Sorption/Retardation

A detailed assessment of sorption in the aquifer at the Site was presented in *EPA Procedural Assessment of MNA of Chromium in Groundwater at SMC Site* (TRC 2013). Sorption describes the partitioning of the contaminant between the dissolved (ground water) and solid matrix (i.e., iron oxides and clay minerals in soil), which results in the retardation of the transport of the contaminant within the dissolved phase. Sorption is described by the Retardation Coefficient, R_d, which is estimated using the following equation (USEPA 1996):

$$R_d = 1 + \frac{\rho_b K_d}{n}$$

where: ρ_b is the soil bulk density; n is the total porosity; and

K_d is the distribution coefficient = Concentration of contaminant in soil (C_s) / Co-located equilibrium concentration of contaminant in groundwater (C_w).

Since physical-chemical processes that govern the fate and transport of chromium in the aquifer under the SMC Site are mainly iron-based, interrelated and dependent on aquifer geochemistry, it may be difficult to always separate sorption from other processes. Therefore, sorption was simulated as part of a bulk attenuation process that incorporates the effects of both sorption and chemical reduction/precipitation. The combined process can be represented by first-order bulk attenuation factors as described below. Consistent with this approach, the retardation factor was conservatively maintained at or close to 1.0 for all simulations (a retardation factor of 1.1 to 1.4 represents the lower end based on site data).

Plume Attenuation/Decay

This process represents the effects of geochemical processes that remove chromium from groundwater including reduction of hexavalent iron to sparingly soluble chromium hydroxide by ferrous iron and co-precipitation and complexation with metal (predominantly iron) oxides or oxyhydroxides. As noted above, sorption was simulated with chemical reduction/precipitation as a combined bulk attenuation process

Bulk attenuation was simulated by a first-order decay model, which was represented in BIOSCREEN by a bulk attenuation factor which could be calculated based on the change of chromium concentrations over time at different locations. Alternatively, the bulk attenuation factor can be quantified as the product of groundwater seepage velocity and the decrease in chromium concentration with distance along a groundwater flowpath. For this model, the latter method is used. Changes in chromium concentrations were evaluated along four groundwater flowpaths: two in the upper aquifer and two in the lower aquifer as follows:

- Upper Aquifer: Flowpaths extending from U7-B to SC-2I and from U6-A to U8-E;
- Lower Aquifer: Flowpaths extending from L7-C1 to L8-A2 and from L7-D2 to L9-B2.

Based upon concentration reductions along these flowpaths and groundwater seepage rates, bulk attenuation rates for the upper and lower aquifers were estimated to range from approximately 0.004 to 0.023 day^{-1} and from 0.0005 to 0.003 day^{-1}, respectively. Calculations of the bulk attenuation factors are presented in TRC's February 14, 2013 memorandum to EPA (TRC 2013).

It should be noted that these values are representative of the combination of physical and chemical attenuation processes including sorption.

Source Characteristics

The source zone characteristics used by BIOSCREEN to simulate fate and transport include:

- The source length perpendicular to the direction of groundwater flow;
- The source strength;
- The source thickness; and
- The source mass.

Model Calibration

These parameters were treated as calibrated parameters and estimated based on a sensitivity analysis. The first two parameters were approximated based on actual field conditions. For model calibration, the length of the source in the upper and lower aquifers was defined by the inferred width of the plume based upon the inferred 100 µg/l total chromium isoconcentration contour at transect U7/L7 based upon data collected during April 2012 prior to CPS injection. Likewise, the source strength was based upon pre-injection concentrations of total chromium in the monitoring wells located along this transect since the concentrations along this transect are generally representative of the highest pre-injection chromium concentrations in ground water at the Farm Parcel CPS Injection Area.

The thickness of the source zone (zone of higher concentrations and sorbed mass) in the upper and lower aquifer was estimated during the design for CPS injections to range from approximately 5 to 10 feet, with the source in the upper aquifer trending towards the higher end of the range. For fate and transport simulations performed for the plume in the upper aquifer, the source thickness was varied between 8 feet and 9 feet. Source thickness and was maintained at 7 feet for the simulations in the lower aquifer.

The soluble chromium mass at the source in the upper and lower aquifers at the Farm Parcel area was approximated to the total chromium mass for the corresponding zone within the 100 µg/L isopleths downgradient of the Car Wash area:

- A thickness that varies from approximately 30 to 60 feet;
- A width that varies from approximately 400 feet to 500 feet;
- A length between approximately 1,200 and 1,500 feet;

- Porosity at 0.3 to 0.4; and
- Equivalent (weighted average of dissolved and sorbed) concentrations of 10 to 30 mg/L.

Accordingly, conservative estimates of chromium source mass used to calibrate the model was varied from 3,500 kilograms (kg) to 3,800 kg in the upper aquifer and from 5,000 kg to 10,000 kg in the lower aquifer.

Simulations to Establish Concentration Targets for Farm Parcel Treatment Area

To establish concentration targets at the Farm Parcel Treatment Area, chromium sources for the upper and lower plumes were modeled to generally coincide with area where the chromium plume intersects the eastern boundary of the Farm Parcel. This location corresponds to the leading edge of the highest post-injection concentrations of chromium in the Farm Parcel Treatment Area. The width of the source for these simulations is defined by the 100 µg/l isoconcentration contour is based upon post-injection concentrations of total chromium from October 2012.

To derive concentration targets, chromium mass in the source zone was reduced to 12.5 percent of the mass used for calibration for the simulations where the bulk attenuation rate constant was used to account for all physical and geochemical attenuation processes including sorption. This reduction is based upon the following:

- The initial CPS injections were designed to reduce the original mass by 75%.
- Polishing injections will be designed at a minimum to reduce the remaining mass (25%) by 50% (25% x 0.5 = 12.5% of the original mass).

Holding other parameters constant, source concentrations were incrementally reduced for each set of parameters that achieved calibration until concentrations at wells located at the perimeter of the Farm Parcel were less than the 100 µg/l remediation criterion for total chromium established by EPA and the 70 µg/l NJDEP groundwater standard. The resulting source concentration represents the concentration target for the Farm Parcel Treatment Area that can be mitigated by MNA.

Simulations to Evaluate Attenuation of Chromium in Groundwater at Car Wash Area

Simulations were performed using input data from each calibration run to evaluate the attenuation of chromium in the area between the Facility and Farm Parcel Treatment Area in the absence of continued pumping the Car Wash extraction wells. For these simulations, the source was simulated at the location of the Car Wash extraction wells. The width and strength of the source was based upon total chromium concentrations detected at the Car Wash Area during

April 2013 and the source mass was conservatively set to 25 percent of the mass used to achieve calibration (i.e., 25% of the pre-CPS injection mass upgradient of the car Wash area). These simulations were used to predict maximum concentrations of chromium that could migrate from the Car Wash area to wells located on the Farm Parcel with shutdown of the Car Wash Extraction Wells. The concentrations predicted at these wells were combined with predicted concentrations at these same wells from the simulations of post-CPS injection chromium concentrations at the Farm Parcel to evaluate if the aquifer had capacity to attenuate chromium concentrations at the Car Wash area.

Table A.2.1
Summary of Calibration Input Data
for MNA Modeling Using Bioscreen
Sorption and Chemical Reduction Simulated as Combined Process
Shield Alloy Site
New Jersey

Input Parameter	Range of Values	Simulation			Source of Data
Upper Aquifer		4a	4aR1	5aR1	
			Advection Parameters		
Hydraulic Conductivity	250 to 706 ft/day	252 ft/day	252 ft/day	255 ft/day	Based on transmissivity at SC-S3, IW-1, and IW-2 and range of saturated thickness of upper zone in area of Farm Parcel (50 to 55 feet)
Hydraulic Gradient	0.0017	0.0017	0.0017	0.0017	Measured on Farm Parcel downgradient of pumping wells using April 2012 data. Reasonable approximateion
Effective Porosity	0.25 to 0.35	0.3	0.2	0.35	Literature Value - medium to coarse gravelly Sand (Walton, 1991)
Seepage Velocity	443 to 1,752 ft/yr	522 ft/yr	783 ft/yr	452 ft/yr	Calculated from Initial Input Data
			Dispersion Parameters		
Plume Length	1,000 to 1,500 feet	1000 feet	1000 feet	1500 feet	Reasonable Estimate in absence of pumping. Impacts traveled from Shield Alloy to Farm Parcel
Longitudinal Dispersion	24 to 29 ft	24.5 ft	24.5 ft	28.9 ft	Calculated by Model
Transverse Dispersion	2 to 3 ft	2.4 ft	2.4 ft	2.9 ft	Calculated by Model
Vertical Dispersion	0 ft	0.0 ft	0.0 ft	0.0 ft	Calculated by Model
			Adsorption Parameters		
Retardation Factor	see note [1]	1.0[1]	1.0[1]	1.0[1]	
Soil Bulk Density	---	Not used [1]	Not used [1]	Not used [1]	
Distribution Coefficient, Kd	---	Not used [1]	Not used [1]	Not used [1]	
			Attenuation Factor		
Bulk Attenuation Factor (Lab)	0.01 to 0.013 per day	–	–	–	From Laboratory Treatability Studies for Shield Alloy
(Field)	0.004 to 0.023 oer day	0.005 per day	0.005 per day	0.005 per day	Calculated from total chromium concentration pre-injection data along transects U6-A to U8-E and U7B to SC-2I
Simulation Time	30 years	30 years	30 years	30 years	Plume has existed for decades. 30 years reasonable timeframe to simulate steady state plume condition.
			Source Data		
Source Thickness in Sat. Zone	<10 feet	8 feet	7 feet	9 feet	Investigations by TRC indicate that the source zone (highest concentrations) are present in a thin zone less than 10 feet in thickness (Verbal communication with Nidal Rabah)..
	Plume Width	Concentration	Concentration	Concentration	Estimated from pre-injection data for total chromium for transect extending from U7-A northwest to U7-C. Used for calibration.
	80 ft	0.7 mg/l	0.7 mg/l	0.5 mg/l	
	80 ft	5 mg/l	5 mg/l	7 mg/l	
	75 ft	15 mg/l	13.5 mg/l	18 mg/l	
Soluble mass	2000 to 5000 kg	3,500 kg	3,500 kg	3,800 kg	Estimated during previous studies by TRC (Verbal Communication with Nidal Rabah).

Table A.2.1
Summary of Calibration Input Data
for MNA Modeling Using Bioscreen
Sorption and Chemical Reduction Simulated as Combined Process
Shield Alloy Site
New Jersey

Input Parameter	Value	Simulation			Source of Data
Lower Aquifer		5	6	7	
Advection Parameters					
Hydraulic Conductivity	64 to 137 ft/day	102 ft/day	102 ft/day	68 ft/day	Based on transmissivities calculated from drawdown data at SC-6D during pumping of RW-6D and saturated thickness of 55 feet.
Hydraulic Gradient	0.0016	0.0016	0.0016	0.0016	Measured on Farm Parcel downgradient of pumping wells using April 2012 data
Effective Porosity	0.1 to 0.3	0.2	0.2	0.25	Literature Value - Silty Sand (Walton, 1991)
Seepage Velocity	140 to 300 ft/yr	298 ft/yr	298 ft/yr	158.9 ft/yt	Calculated from Initial Input Data
Dispersion Parameters					
Plume Length	1000 feet	1000 feet	1000 feet	1000 feet	Reasonable Estimate in absence of pumping. Impacts traveled from Shield Alloy to Farm Parcel
Longitudinal Dispersion	24.5 ft	24.5 ft	24.5 ft	24.5 ft	Calculated by Model
Transverse Dispersion	2.4 ft	2.4 ft	2.4 ft	2.4 ft	Calculated by Model
Vertical Dispersion	0 ft	0 ft	0 ft	0 ft	Calculated by Model
Adsorption Parameters					
Retardation Factor	1.0 to 1.3	1.3	1.0[(1)]	1.0[(1)]	Adsorption of chromium is generally accounted for by the bulk attenuation factor. A slight increase in retardation factor was used as a calibration parameter for run 5.
Soil Bulk Density	---	Not used [(1)]	Not used [(1)]	Not used [(1)]	
Distribution Coefficient, Kd	---	Not used [(1)]	Not used [(1)]	Not used [(1)]	
Attenuation Factor					
Bulk Attenuation Factor (Lab)	0.01 to 0.045 per day	--	--	--	From Laboratory Treatability Studies for Shieldalloy
(Field)	0.0005 to 0.003 oer day	0.0023 per day	0.0027 per day	0.0017 per day	Calculated from total Chromium Concentration pre-injection Data along transects L7-C1 to L9-A2 and L7-D2 to L9-B2
General Parameters					
Simulation Time	30 years	30 years	30 years	30 years	Plume has existed for decades. 30 years reasonable timeframe to simulate steady state plume condition.
Source Data					
Source Thickness in Sat. Zone	<10 feet	7 feet	7 feet	7 feet	Investigations by TRC indicate that the source zone (highest concentrations) are present in a thin zone less than 10 feet in thickness (Verbal communication with Nidal Rabah)..
	Plume Width	Concentration	Concentration	Concentration	
	90 ft	0.5 mg/l	0.5 mg/l	0.5 mg/l	Estimated from pre-injection data for total chromium for transect extending from L7-A1 southeast to L7-D1. Used for calibration.
	65 ft	9.5 mg/l	9.5 mg/l	9.5 mg/l	
	230 ft	14.5 mg/l	14.5 mg/l	15 mg/l	
Soluble mass	5,000 to 10,000 kg	10,000 kg	9,000 kg	5,000 kg	Estimated during previous studies by TRC (Verbal Communication with Nidal Rabah).

Notes:

(1) - Sorption was addressed in the application of a bulk attenuation factor that accounts for all attenuation processes including sorption.

Walton, W.C., 1991. Principles of Groundwater Engineering. Lewis Publishers. Boca Raton, Florida

ATTACHMENT 3
BIOSCREEN MODEL OUTPUT
MODEL CALIBRATION

BIOSCREEN Natural Attenuation Decision Support System

Air Force Center for Environmental Excellence
Calibration Run 4 a Upper Plume Shield Alloy

Version 1.4

Upper Cr Plume
Shield Alloy
Run Name

Data Input Instructions:

115
or
0.02

1. Enter value directly....or
2. Calculate by filling in grey cells below. (To restore formulas, hit button below).

Variable* → Data used directly in model.
20 → Value calculated by model. (Don't enter any data).

1. HYDROGEOLOGY

Seepage Velocity*	Vs	521.8	(ft/yr)
or		or	
Hydraulic Conductivity	K	8.9E-02	(cm/sec)
Hydraulic Gradient	i	0.0017	(ft/ft)
Porosity	n	0.3	(-)

2. DISPERSION

Longitudinal Dispersivity*	alpha x	24.5	(ft)
Transverse Dispersivity*	alpha y	2.4	(ft)
Vertical Dispersivity*	alpha z	0.0	(ft)
or		or	
Estimated Plume Length	Lp	1000	(ft)

3. ADSORPTION

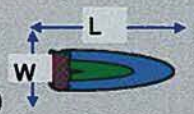
Retardation Factor*	R	1.0	(-)
or		or	
Soil Bulk Density	rho	1.7	(kg/l)
Partition Coefficient	Koc	38	(L/kg)
FractionOrganicCarbon	foc	5.7E-5	(-)

4. GEOCHEMICAL ATTENUATION

1st Order Bulk Att Factor*	lambda	1.8E+0	(per yr)
or		or	
Solute Half-Life	t-half	0.38	(year)
or Instantaneous Reaction Model			
Delta Oxygen*	DO	0	(mg/L)
Delta Nitrate*	NO3	0	(mg/L)
Observed Ferrous Iron*	Fe2+	0	(mg/L)
Delta Sulfate*	SO4	0	(mg/L)
Observed Methane*	CH4	0	(mg/L)

5. GENERAL

Modeled Area Length*	2000	(ft)
Modeled Area Width*	800	(ft)
Simulation Time*	30	(yr)



6. SOURCE DATA

Source Thickness in Sat.Zone* 8 (ft)

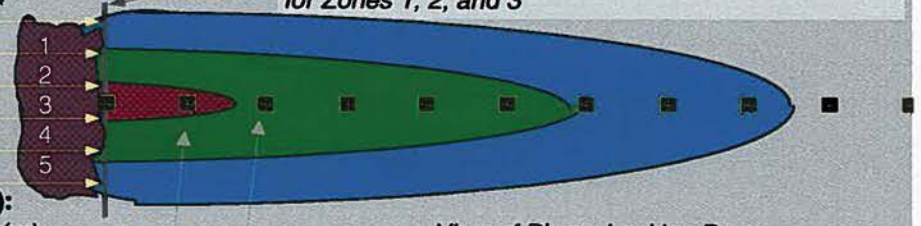
Source Zones:

Width* (ft)	Conc. (mg/L)*
80	0.7
80	5
75	15
80	5
80	0.7

Source Halflife (see Help):

30	30	(yr)
Inst. React.	1st Order	
Soluble Mass	3500	(Kg)
In Source NAPL, Soil		

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3



View of Plume Looking Down

Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

7. FIELD DATA FOR COMPARISON

Dist. from Source (ft)	Concentration (mg/L)
0	8.31
200	3.58
400	
600	
800	
1000	
1200	
1400	
1600	
1800	
2000	

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN — **View Output**

RUN ARRAY — **View Output**

Help | Recalculate

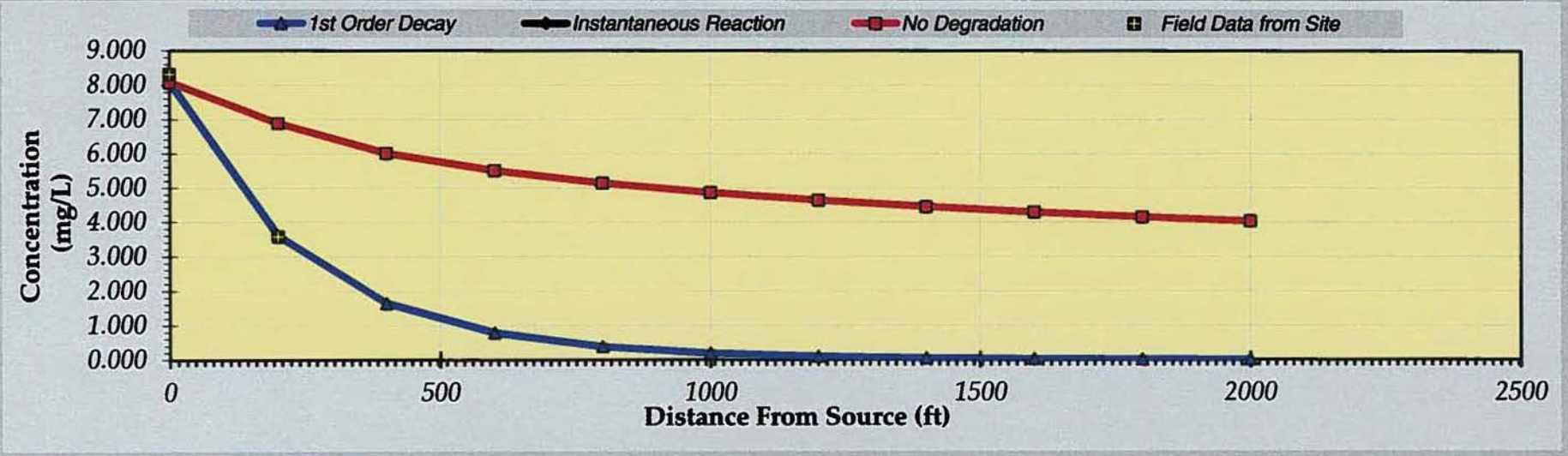
Paste Example Dataset

Restore Formulas for Vs,

CALIBRATION RUN 4A

UPPER PLUME DISSOLVED CHROMIUM CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

TYPE OF MODEL	Distance from Source (ft) 0	200	400	600	800	1000	1200	1400	1600	1800	2000
No Degradation	8.079	6.890	6.018	5.504	5.141	4.861	4.635	4.447	4.287	4.148	4.027
1st Order Decay	8.079	3.605	1.648	0.789	0.385	0.191	0.095	0.048	0.024	0.012	0.006
Inst. Reaction	8.079	6.890	6.018	5.504	5.141	4.861	4.635	4.447	4.287	4.148	4.027
Field Data from Site	8.310	3.580									



Calculate

Time: 30 Years

Return to

Recalculate This

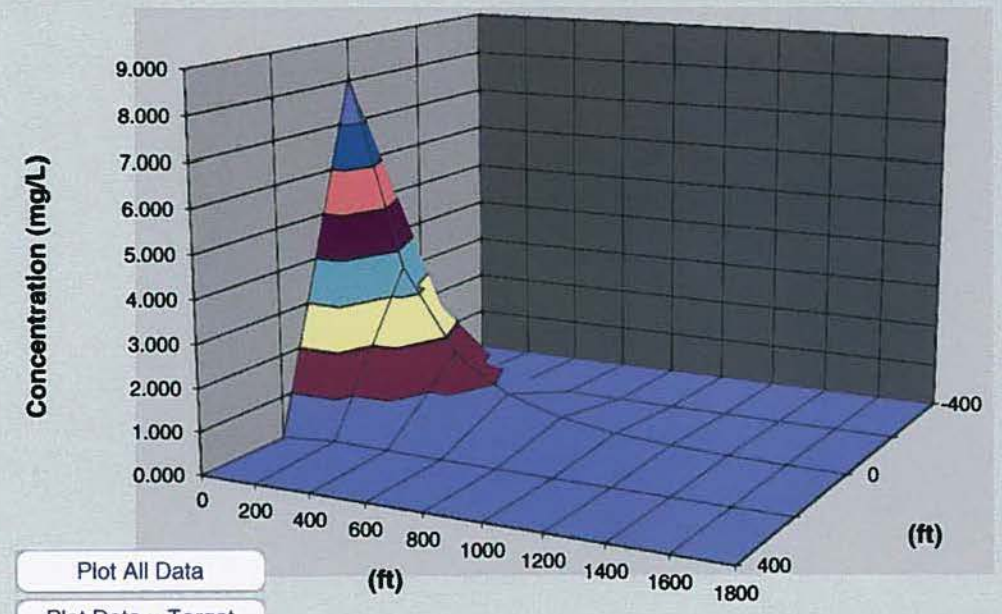
CALIBRATION RUN 4A UPPER PLUME DISSOLVED CHROMIUM CONCENTRATIONS IN PLUME (mg/L at Z=0)

Transverse Distance (ft) ↓ / Distance from Source (ft) →	0	200	400	600	800	1000	1200	1400	1600	1800	2000
400	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
200	0.000	0.098	0.070	0.049	0.033	0.021	0.013	0.008	0.004	0.003	0.001
0	8.079	3.605	1.648	0.789	0.385	0.191	0.095	0.048	0.024	0.012	0.006
-200	0.000	0.098	0.070	0.049	0.033	0.021	0.013	0.008	0.004	0.003	0.001
-400	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MASS FLUX (mg/day)	2.0E+5	7.4E+4	3.5E+4	1.7E+4	8.8E+3	4.5E+3	2.3E+3	1.2E+3	6.4E+2	3.4E+2	1.8E+2

Model to Display:

- *No Degradation*
- *1st Order Decay*
- *Instantaneous*

Time: **30 Years** Target Level: **0.100** mg/L Displayed Model: **1st Order Decay**



Plot All Data

Plot Data > Target

Plume and Source Masses (Order-of-Magnitude Accuracy)

Plume Mass if No Biodegradation	Can't Calc.	*(Kg)*
- Actual Plume Mass	Can't Calc.	*(Kg)*
= Plume Mass Removed by Biodeg	-	*(Kg)*

Change in Electron Acceptor/Byproduct Masses:

Oxygen	*Nitrate*	*Iron II*	*Sulfate*	*Methane*	
na	na	na	na	na	*(Kg)*

Contam. Mass in Source (t=0 Years)	3500.0	*(Kg)*
Contam. Mass in Source Now (t=30Years)	1885.1	*(Kg)*
Current Volume of Groundwater in Plume	Can't Calc.	*(ac-ft)*
Flowrate of Water Through Source Zone	Can't Calc.	*(ac-ft/yr)*

Mass HELP

Recalculat

BIOSCREEN Natural Attenuation Decision Support System

Air Force Center for Environmental Excellence
Calibration Run 4a r1 Upper Plume Shield Alloy

Version 1.4

Upper Cr Plume
Shield Alloy
Run Name

Data Input Instructions:

115 ↑ or 0.02
1. Enter value directly....or
2. Calculate by filling in grey cells below. (To restore formulas, hit button below).

Variable* → Data used directly in model.
20 → Value calculated by model. (Don't enter any data).

1. HYDROGEOLOGY

Seepage Velocity*	Vs	782.7	(ft/yr)
or		↑ or	
Hydraulic Conductivity	K	8.9E-02	(cm/sec)
Hydraulic Gradient	i	0.0017	(ft/ft)
Porosity	n	0.2	(-)

2. DISPERSION

Longitudinal Dispersivity*	alpha x	24.5	(ft)
Transverse Dispersivity*	alpha y	2.4	(ft)
Vertical Dispersivity*	alpha z	0.0	(ft)
or		↑ or	
Estimated Plume Length	Lp	1000	(ft)

3. ADSORPTION

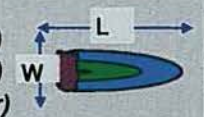
Retardation Factor*	R	1.0	(-)
or		↑ or	
Soil Bulk Density	rho	1.7	(kg/l)
Partition Coefficient	Koc	38	(L/kg)
FractionOrganicCarbon	foc	5.7E-5	(-)

4. GEOCHEMICAL ATTENUATION

1st Order Bulk Att Factor*	lambda	1.8E+0	(per yr)
or		↑ or	
Solute Half-Life	t-half	0.38	(year)
or Instantaneous Reaction Model			
Delta Oxygen*	DO	0	(mg/L)
Delta Nitrate*	NO3	0	(mg/L)
Observed Ferrous Iron*	Fe2+	0	(mg/L)
Delta Sulfate*	SO4	0	(mg/L)
Observed Methane*	CH4	0	(mg/L)

5. GENERAL

Modeled Area Length*	2000	(ft)
Modeled Area Width*	800	(ft)
Simulation Time*	30	(yr)



6. SOURCE DATA

Source Thickness in Sat.Zone* 7 (ft)

Source Zones:

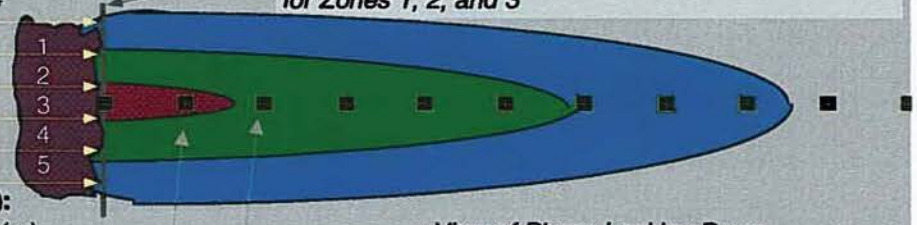
Width* (ft)	Conc. (mg/L)*
80	0.7
80	5
75	13.5
80	5
80	0.7

Source Halflife (see Help):

Inst. React.	1st Order	
40	40	(yr)

Soluble Mass 3500 (Kg)
In Source NAPL, Soil

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3



View of Plume Looking Down

Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

7. FIELD DATA FOR COMPARISON

Dist. from Source (ft)	Concentration (mg/L)
0	8.31
200	3.58
400	
600	
800	
1000	
1200	
1400	
1600	
1800	
2000	

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN — View Output

RUN ARRAY — View Output

Help — Recalculate

Paste Example Dataset

Restore Formulas for Vs,

CALIBRATION RUN 4A 1

UPPER PLUME DISSOLVED CHROMIUM CONCENTRATION ALONG CENTERLINE (mg/L at Z=0)

TYPE OF MODEL	Distance from Source (ft) 0	200	400	600	800	1000	1200	1400	1600	1800	2000
No Degradation	8.094	6.948	6.104	5.597	5.230	4.941	4.705	4.505	4.333	4.182	4.050
1st Order Decay	8.094	4.490	2.549	1.510	0.912	0.557	0.343	0.212	0.132	0.082	0.051
Inst. Reaction	8.094	6.948	6.104	5.597	5.230	4.941	4.705	4.505	4.333	4.182	4.050
Field Data from Site	8.310	3.580									

Calculate

Time: 30 Years

Return to

Recalculate This

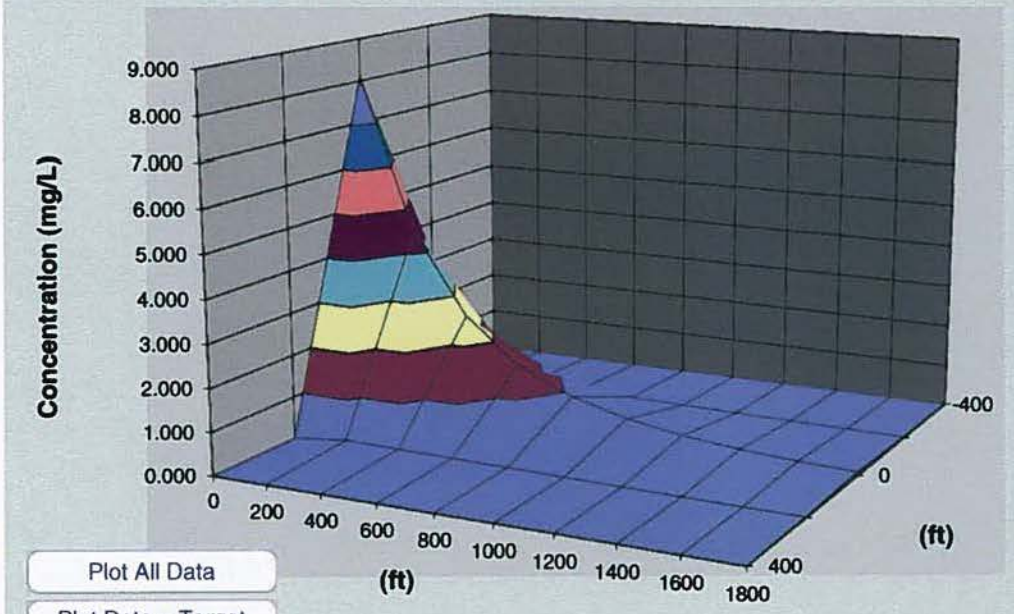
Transverse CALIBRATION RUN 4A R1 - UPPER PLUME DISSOLVED CHROMIUM CONCENTRATIONS IN PLUME (mg/L at Z=0)

Distance (ft) ↓ / Distance from Source (ft)	0	200	400	600	800	1000	1200	1400	1600	1800	2000
400	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
200	0.000	0.135	0.119	0.102	0.083	0.065	0.049	0.036	0.025	0.018	0.012
0	8.094	4.490	2.549	1.510	0.912	0.557	0.343	0.212	0.132	0.082	0.051
-200	0.000	0.135	0.119	0.102	0.083	0.065	0.049	0.036	0.025	0.018	0.012
-400	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MASS FLUX (mg/day)	1.6E+5	8.1E+4	4.7E+4	2.9E+4	1.8E+4	1.2E+4	7.5E+3	4.8E+3	3.1E+3	2.0E+3	1.3E+3

Model to Display:

- *No Degradation*
- *1st Order Decay*
- *Instantaneous*

Time: **30 Years** Target Level: **0.100** mg/L Displayed Model: **1st Order Decay**



Plot All Data

Plot Data > Target

Plume and Source Masses (Order-of-Magnitude Accuracy)

Plume Mass if No Biodegradation	Can't Calc.	*(Kg)*
- Actual Plume Mass	Can't Calc.	*(Kg)*
= Plume Mass Removed by Biodeg	-	*(Kg)*

Change in Electron Acceptor/Byproduct Masses:

Oxygen	*Nitrate*	*Iron II*	*Sulfate*	*Methane*	
na	na	na	na	na	*(Kg)*

Contam. Mass in Source (t=0 Years)	3500.0	*(Kg)*
Contam. Mass in Source Now (t=30Years)	2098.5	*(Kg)*
Current Volume of Groundwater in Plume	Can't Calc.	*(ac-ft)*
Flowrate of Water Through Source Zone	Can't Calc.	*(ac-ft/yr)*

Mass HELP

Recalculat

BIOSCREEN Natural Attenuation Decision Support System

Air Force Center for Environmental Excellence
Calibration Run 5a r1 Upper Plume Shield Alloy

Version 1.4

Upper Cr Plume
Shield Alloy
Run Name

Data Input Instructions:

115 → 1. Enter value directly....or
↑ or
0.02 → 2. Calculate by filling in grey cells below. (To restore formulas, hit button below).

Variable* → Data used directly in model.
20 → Value calculated by model. (Don't enter any data).

1. HYDROGEOLOGY

Seepage Velocity*	Vs	452.3	(ft/yr)
or		↑ or	
Hydraulic Conductivity	K	9.0E-02	(cm/sec)
Hydraulic Gradient	i	0.0017	(ft/ft)
Porosity	n	0.35	(-)

2. DISPERSION

Longitudinal Dispersivity*	alpha x	28.9	(ft)
Transverse Dispersivity*	alpha y	2.9	(ft)
Vertical Dispersivity*	alpha z	0.0	(ft)
or		↑ or	
Estimated Plume Length	Lp	1500	(ft)

3. ADSORPTION

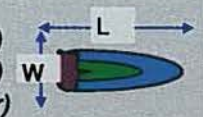
Retardation Factor*	R	1.0	(-)
or		↑ or	
Soil Bulk Density	rho	1.7	(kg/l)
Partition Coefficient	Koc	38	(L/kg)
FractionOrganicCarbon	foc	5.7E-5	(-)

4. GEOCHEMICAL ATTENUATION

1st Order Bulk Att Factor*	lambda	1.7E+0	(per yr)
or		↑ or	
Solute Half-Life	t-half	0.40	(year)
or Instantaneous Reaction Model			
Delta Oxygen*	DO	0	(mg/L)
Delta Nitrate*	NO3	0	(mg/L)
Observed Ferrous Iron*	Fe2+	0	(mg/L)
Delta Sulfate*	SO4	0	(mg/L)
Observed Methane*	CH4	0	(mg/L)

5. GENERAL

Modeled Area Length*	2000	(ft)
Modeled Area Width*	800	(ft)
Simulation Time*	30	(yr)



6. SOURCE DATA

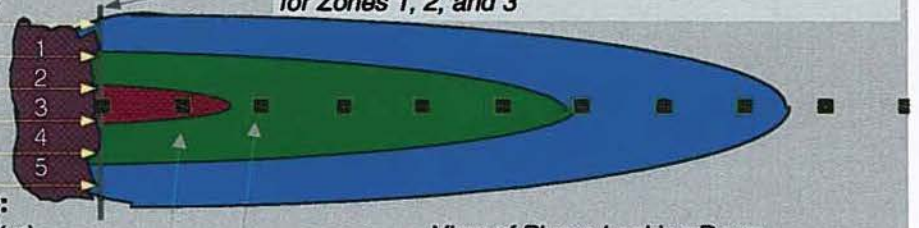
Source Thickness in Sat.Zone* 9 (ft)

Source Zones:

Width* (ft)	Conc. (mg/L)*
80	0.5
80	7
75	18
80	7
80	0.5

Source Halflife (see Help):		
30	30	(yr)
Inst. React. ↑	↑ 1st Order	
Soluble Mass	3800	(Kg)
In Source NAPL, Soil		

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3



View of Plume Looking Down

Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

7. FIELD DATA FOR COMPARISON

Dist. from Source (ft)	Concentration (mg/L)
0	8.31
200	3.58
400	
600	
800	
1000	
1200	
1400	
1600	
1800	
2000	

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN — **View Output**

RUN ARRAY — **View Output**

Help | Recalculate

Paste Example Dataset

Restore Formulas for Vs,

CALIBRATION RUN 5AR1 **UPPER PLUME DISSOLVED CHROMIUM CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)**

	Distance from Source (ft)										
TYPE OF MODEL	0	200	400	600	800	1000	1200	1400	1600	1800	2000
No Degradation	7.994	6.754	5.966	5.494	5.152	4.886	4.670	4.490	4.339	4.209	4.097
1st Order Decay	7.994	3.367	1.483	0.681	0.318	0.150	0.072	0.034	0.017	0.008	0.004
Inst. Reaction	7.994	6.754	5.966	5.494	5.152	4.886	4.670	4.490	4.339	4.209	4.097
Field Data from Site	8.310	3.580									

Calculate

Time: 30 Years

Return to

Recalculate This

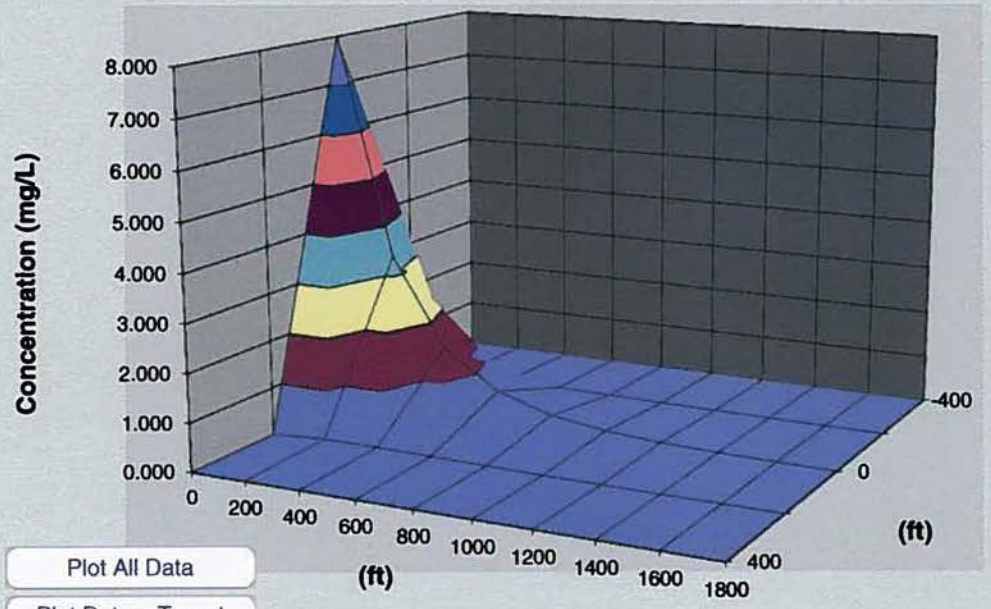
Transverse Distance (ft) — CALIBRATION RUN 5A R1 UPPER PLUME DISSOLVED CHROMIUM CONCENTRATIONS IN PLUME (mg/L at Z=0)

Distance from Source (ft)

↓	0	200	400	600	800	1000	1200	1400	1600	1800	2000
400	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
200	0.000	0.064	0.059	0.045	0.031	0.019	0.011	0.006	0.004	0.002	0.001
0	7.994	3.367	1.483	0.681	0.318	0.150	0.072	0.034	0.017	0.008	0.004
-200	0.000	0.064	0.059	0.045	0.031	0.019	0.011	0.006	0.004	0.002	0.001
-400	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MASS FLUX (mg/day)	2.8E+5	7.7E+4	3.5E+4	1.7E+4	8.4E+3	4.2E+3	2.1E+3	1.0E+3	5.3E+2	2.7E+2	1.3E+2

Model to Display: No Degradation | 1st Order Decay | Instantaneous

Time: 30 Years Target Level: 0.100 mg/L Displayed Model: 1st Order Decay



Plot All Data

Plot Data > Target

Plume and Source Masses (Order-of-Magnitude Accuracy)

Plume Mass if No Biodegradation: Can't Calc. (Kg)

- Actual Plume Mass: Can't Calc. (Kg)

= Plume Mass Removed by Biodeg: - (Kg)

Change in Electron Acceptor/Byproduct Masses:

Oxygen	*Nitrate*	*Iron II*	*Sulfate*	*Methane*	
na	na	na	na	na	(Kg)

Contam. Mass in Source (t=0 Years): 3800.0 (Kg)

Contam. Mass in Source Now (t=30Years): 1687.6 (Kg)

Current Volume of Groundwater in Plume: Can't Calc. (ac-ft)

Flowrate of Water Through Source Zone: Can't Calc. (ac-ft/yr)

Mass HELP

Recalculat

BIOSCREEN Natural Attenuation Decision Support System

Air Force Center for Environmental Excellence
Run 5 Calibration of Chromium Attenuation in Lower Aquifer

Version 1.4

Lower Cr Plume
Shield Alloy
Run Name

Data Input Instructions:

1. Enter value directly....or
2. Calculate by filling in grey cells below. (To restore formulas, hit button below).

Variable* — Data used directly in model.
Value calculated by model. (Don't enter any data).

1. HYDROGEOLOGY

Seepage Velocity*	Vs	298.0	(ft/yr)
or		or	
Hydraulic Conductivity	K	3.6E-02	(cm/sec)
Hydraulic Gradient	i	0.0016	(ft/ft)
Porosity	n	0.2	(-)

2. DISPERSION

Longitudinal Dispersivity*	alpha x	24.5	(ft)
Transverse Dispersivity*	alpha y	2.4	(ft)
Vertical Dispersivity*	alpha z	0.0	(ft)
or		or	
Estimated Plume Length	Lp	1000	(ft)

3. ADSORPTION

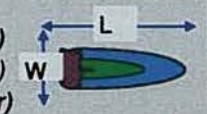
Retardation Factor*	R	1.3	(-)
or		or	
Soil Bulk Density	rho	1.7	(kg/l)
Partition Coefficient	Koc	1000	(L/kg)
FractionOrganicCarbon	foc	5.7E-6	(-)

4. GEOCHEMICAL ATTENUATION

1st Order Bulk Att Factor*	lambda	8.3E-1	(per yr)
or		or	
Solute Half-Life	t-half	0.83	(year)
or Instantaneous Reaction Model			
Delta Oxygen*	DO	0	(mg/L)
Delta Nitrate*	NO3	0	(mg/L)
Observed Ferrous Iron*	Fe2+	0	(mg/L)
Delta Sulfate*	SO4	0	(mg/L)
Observed Methane*	CH4	0	(mg/L)

5. GENERAL

Modeled Area Length*	1000	(ft)
Modeled Area Width*	800	(ft)
Simulation Time*	30	(yr)



115 or 0.02

6. SOURCE DATA

Source Thickness in Sat.Zone* 7 (ft)

Source Zones:

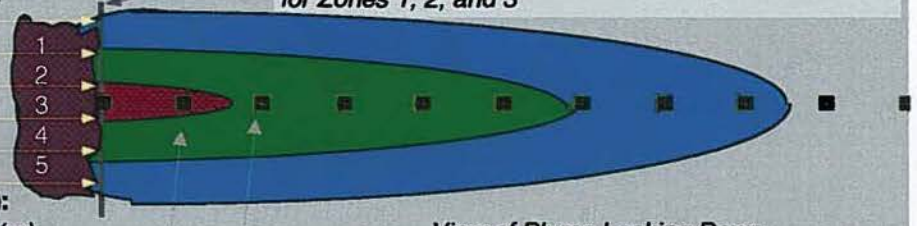
Width* (ft)	Conc. (mg/L)*
90	0.5
65	9.5
230	14.5
65	9.5
90	0.5

Source Halflife (see Help): 100 | 100 (yr)

Inst. React. | 1st Order

Soluble Mass 10000 (Kg)
In Source Soil porewater

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3



View of Plume Looking Down

Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

7. FIELD DATA FOR COMPARISON

Concentration (mg/L)	12.1	10.5	3.4								
Dist. from Source (ft)	0	100	200	300	400	500	600	700	800	900	1000

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN — View Output

RUN ARRAY — View Output

Help

Recalculate

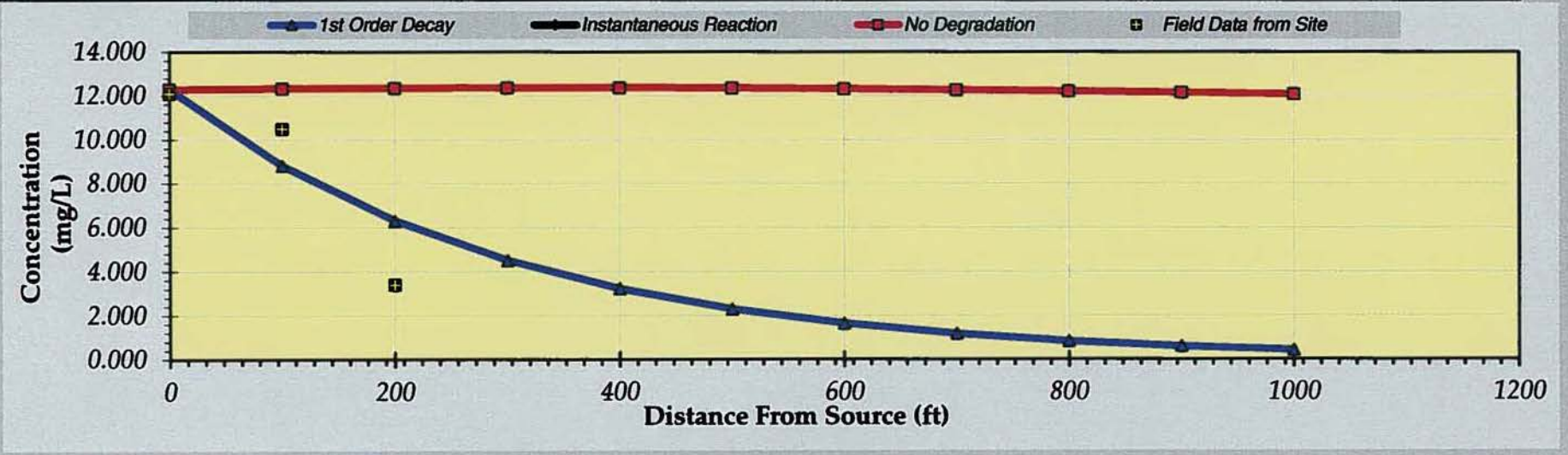
Paste Example Dataset

Restore Formulas for Vs,

CALIBRATION RUN 5

LOWER PLUME DISSOLVED CHROMIUM CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

TYPE OF MODEL	Distance from Source (ft) 0	100	200	300	400	500	600	700	800	900	1000
No Degradation	12.294	12.323	12.352	12.371	12.372	12.354	12.320	12.272	12.215	12.150	12.078
1st Order Decay	12.294	8.802	6.301	4.508	3.220	2.296	1.636	1.164	0.827	0.588	0.417
Inst. Reaction	12.294	12.323	12.352	12.371	12.372	12.354	12.320	12.272	12.215	12.150	12.078
Field Data from Site	12.100	10.500	3.400								



Time: 30 Years

Calculate

Return to

Recalculate This

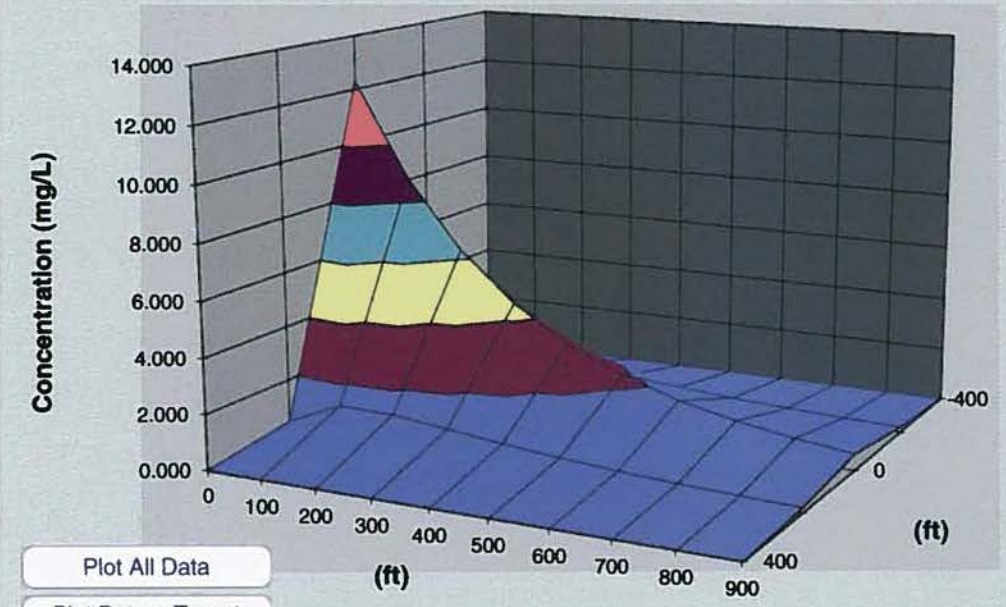
CALIBRATION RUN DISSOLVED CHROMIUM CONCENTRATIONS IN LOWERPLUME (mg/L at Z=0)

Transverse Distance (ft) ↓ / Distance from Source (ft) →	0	100	200	300	400	500	600	700	800	900	1000
400	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001
200	0.424	1.304	1.244	1.014	0.789	0.600	0.451	0.336	0.248	0.183	0.134
0	12.294	8.802	6.301	4.508	3.220	2.296	1.636	1.164	0.827	0.588	0.417
-200	0.424	1.304	1.244	1.014	0.789	0.600	0.451	0.336	0.248	0.183	0.134
-400	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001
MASS FLUX (mg/day)	1.5E+5	7.4E+4	5.7E+4	4.2E+4	3.1E+4	2.3E+4	1.6E+4	1.2E+4	8.6E+3	6.2E+3	4.4E+3

Model to Display:

- No Degradation
- 1st Order Decay
- Instantaneous

Time: **30 Years** Target Level: **0.100** mg/L Displayed Model: **1st Order Decay**



Plot All Data

Plot Data > Target

Plume and Source Masses (Order-of-Magnitude Accuracy)

Plume Mass if No Biodegradation	Can't Calc.	(Kg)
- Actual Plume Mass	Can't Calc.	(Kg)
= Plume Mass Removed by Biodeg	-	(Kg)

Change in Electron Acceptor/Byproduct Masses:

Oxygen	*Nitrate*	*Iron II*	*Sulfate*	*Methane*	
na	na	na	na	na	(Kg)

Contam. Mass in Source (t=0 Years)	10000.0	(Kg)
Contam. Mass in Source Now (t=30Years)	8478.5	(Kg)
Current Volume of Groundwater in Plume	Can't Calc.	(ac-ft)
Flowrate of Water Through Source Zone	Can't Calc.	(ac-ft/yr)

Mass HELP

Recalculat

BIOSCREEN Natural Attenuation Decision Support System

Air Force Center for Environmental Excellence
Run 6 Calibration of Chromium Attenuation in Lower Aquifer

Version 1.4

Lower Cr Plume
Shield Alloy
Run Name

Data Input Instructions:

1. Enter value directly....or
2. Calculate by filling in grey cells below. (To restore formulas, hit button below).

Variable* = Data used directly in model.
Value calculated by model. (Don't enter any data).

1. HYDROGEOLOGY

Seepage Velocity*	Vs	298.0	(ft/yr)
or		or	
Hydraulic Conductivity	K	3.6E-02	(cm/sec)
Hydraulic Gradient	i	0.0016	(ft/ft)
Porosity	n	0.2	(-)

2. DISPERSION

Longitudinal Dispersivity*	alpha x	24.5	(ft)
Transverse Dispersivity*	alpha y	2.4	(ft)
Vertical Dispersivity*	alpha z	0.0	(ft)
or		or	
Estimated Plume Length	Lp	1000	(ft)

3. ADSORPTION

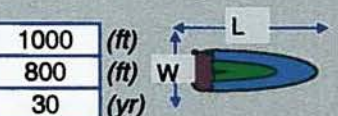
Retardation Factor*	R	1.0	(-)
or		or	
Soil Bulk Density	rho	1.7	(kg/l)
Partition Coefficient	Koc	1000	(L/kg)
FractionOrganicCarbon	foc	5.7E-6	(-)

4. GEOCHEMICAL ATTENUATION

1st Order Bulk Att Factor*	lambda	1.0E+0	(per yr)
or		or	
Solute Half-Life	t-half	0.69	(year)
or Instantaneous Reaction Model			
Delta Oxygen*	DO	0	(mg/L)
Delta Nitrate*	NO3	0	(mg/L)
Observed Ferrous Iron*	Fe2+	0	(mg/L)
Delta Sulfate*	SO4	0	(mg/L)
Observed Methane*	CH4	0	(mg/L)

5. GENERAL

Modeled Area Length*	1000	(ft)
Modeled Area Width*	800	(ft)
Simulation Time*	30	(yr)



115
or
0.02

Variable*
20

6. SOURCE DATA

Source Thickness in Sat.Zone* 7 (ft)

Source Zones:

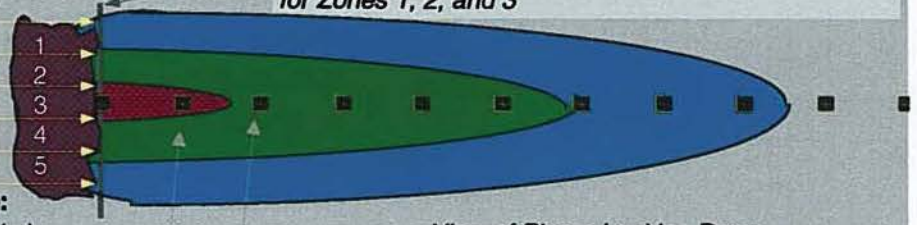
Width* (ft)	Conc. (mg/L)*
90	0.5
65	9.5
230	14.5
65	9.5
90	0.5

Source Halflife (see Help):

Inst. React.	1st Order
100	100 (yr)

Soluble Mass 9000 (Kg)
In Source Soil porewater

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3



View of Plume Looking Down

Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

7. FIELD DATA FOR COMPARISON

Concentration (mg/L)	12.1	10.5	3.4								
Dist. from Source (ft)	0	100	200	300	400	500	600	700	800	900	1000

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN — **View Output**

RUN ARRAY — **View Output**

Help | Recalculate

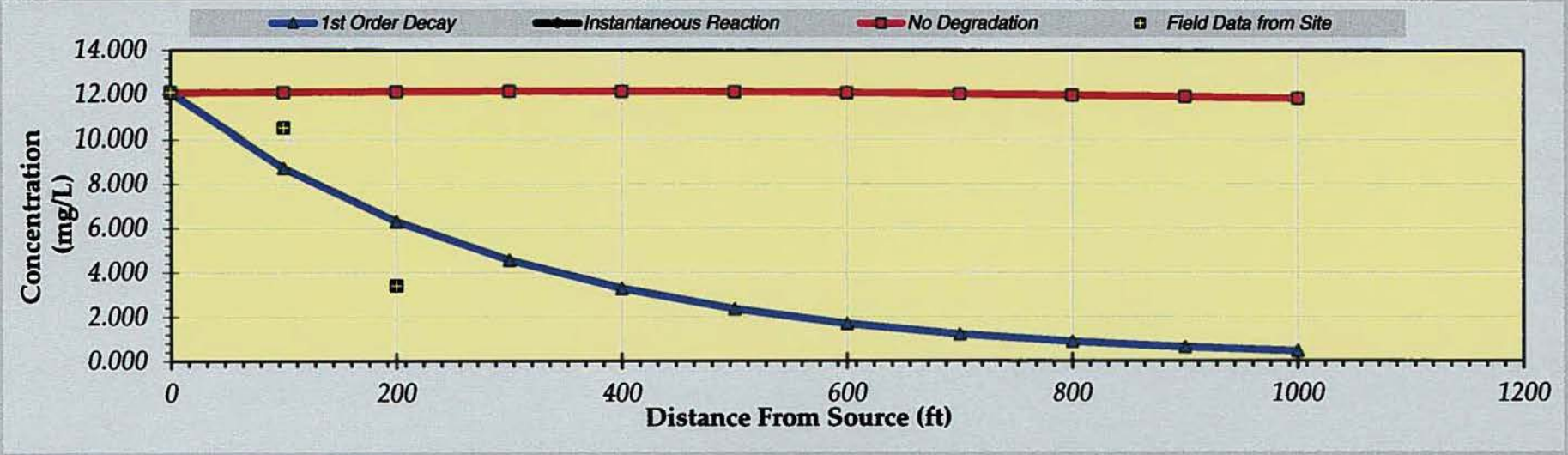
Paste Example Dataset

Restore Formulas for Vs,

CALIBRATION RUN 6

LOWER PLUME DISSOLVED CHROMIUM CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

TYPE OF MODEL	Distance from Source (ft) 0	100	200	300	400	500	600	700	800	900	1000
No Degradation	12.070	12.096	12.122	12.137	12.135	12.114	12.078	12.028	11.969	11.902	11.829
1st Order Decay	12.070	8.721	6.301	4.548	3.279	2.360	1.696	1.218	0.874	0.626	0.449
Inst. Reaction	12.070	12.096	12.122	12.137	12.135	12.114	12.078	12.028	11.969	11.902	11.829
Field Data from Site	12.100	10.500	3.400								



Time: 30 Years

Calculate

Return to

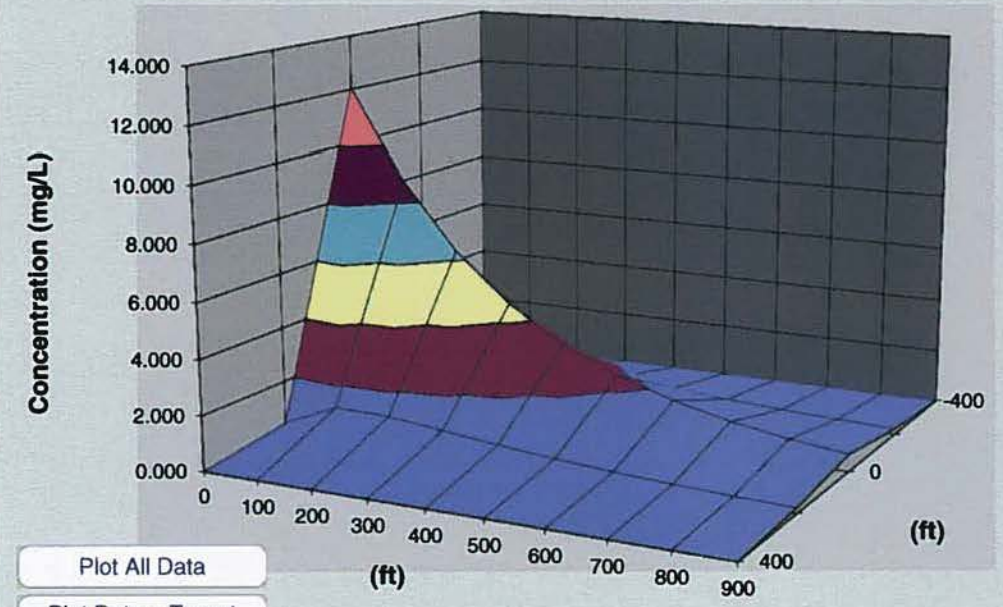
Recalculate This

CALIBRATION RUN 6 DISSOLVED CHROMIUM CONCENTRATIONS IN PLUME (mg/L at Z=0)

Transverse Distance (ft) ↓ / Distance from Source (ft)	0	100	200	300	400	500	600	700	800	900	1000
400	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001
200	0.416	1.292	1.244	1.023	0.803	0.617	0.467	0.351	0.262	0.195	0.144
0	12.070	8.721	6.301	4.548	3.279	2.360	1.696	1.218	0.874	0.626	0.449
-200	0.416	1.292	1.244	1.023	0.803	0.617	0.467	0.351	0.262	0.195	0.144
-400	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001
MASS FLUX (mg/day)	1.5E+5	7.3E+4	5.7E+4	4.3E+4	3.2E+4	2.3E+4	1.7E+4	1.2E+4	9.1E+3	6.6E+3	4.8E+3

Model to Display: No Degradation | 1st Order Decay | Instantaneous

Time: 30 Years Target Level: 0.100 mg/L Displayed Model: 1st Order Decay



Plot All Data

Plot Data > Target

Plume and Source Masses (Order-of-Magnitude Accuracy)

Plume Mass if No Biodegradation	Can't Calc.	(Kg)
- Actual Plume Mass	Can't Calc.	(Kg)
= Plume Mass Removed by Biodeg	-	(Kg)

Change in Electron Acceptor/Byproduct Masses:

Oxygen	Nitrate	Iron II	Sulfate	Methane	
na	na	na	na	na	(Kg)

Contam. Mass in Source (t=0 Years)	9000.0	(Kg)
Contam. Mass in Source Now (t=30Years)	7492.0	(Kg)
Current Volume of Groundwater in Plume	Can't Calc.	(ac-ft)
Flowrate of Water Through Source Zone	Can't Calc.	(ac-ft/yr)

Mass HELP Recalculat

BIOSCREEN Natural Attenuation Decision Support System

Air Force Center for Environmental Excellence
Run 7 Calibration of Chromium Attenuation in Lower Aquifer

Version 1.4

Lower Cr Plume
Shield Alloy
Run Name

Data Input Instructions:

115
↑ or
0.02

1. Enter value directly....or
2. Calculate by filling in grey cells below. (To restore formulas, hit button below).

Variable* → Data used directly in model.
20 → Value calculated by model. (Don't enter any data).

1. HYDROGEOLOGY

Seepage Velocity*	Vs	158.9	(ft/yr)
or		↑ or	
Hydraulic Conductivity	K	2.4E-02	(cm/sec)
Hydraulic Gradient	i	0.0016	(ft/ft)
Porosity	n	0.25	(-)

2. DISPERSION

Longitudinal Dispersivity*	alpha x	24.5	(ft)
Transverse Dispersivity*	alpha y	2.4	(ft)
Vertical Dispersivity*	alpha z	0.0	(ft)
or		↑ or	
Estimated Plume Length	Lp	1000	(ft)

3. ADSORPTION

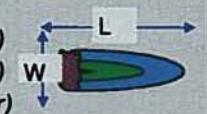
Retardation Factor*	R	1.0	(-)
or		↑ or	
Soil Bulk Density	rho	1.7	(kg/l)
Partition Coefficient	Koc	1000	(L/kg)
FractionOrganicCarbon	foc	5.7E-6	(-)

4. GEOCHEMICAL ATTENUATION

1st Order Bulk Att Factor*	lambda	6.3E-1	(per yr)
or		↑ or	
Solute Half-Life	t-half	1.10	(year)
or Instantaneous Reaction Model			
Delta Oxygen*	DO	0	(mg/L)
Delta Nitrate*	NO3	0	(mg/L)
Observed Ferrous Iron*	Fe2+	0	(mg/L)
Delta Sulfate*	SO4	0	(mg/L)
Observed Methane*	CH4	0	(mg/L)

5. GENERAL

Modeled Area Length*	1000	(ft)
Modeled Area Width*	800	(ft)
Simulation Time*	30	(yr)



6. SOURCE DATA

Source Thickness in Sat.Zone* 7 (ft)

Source Zones:

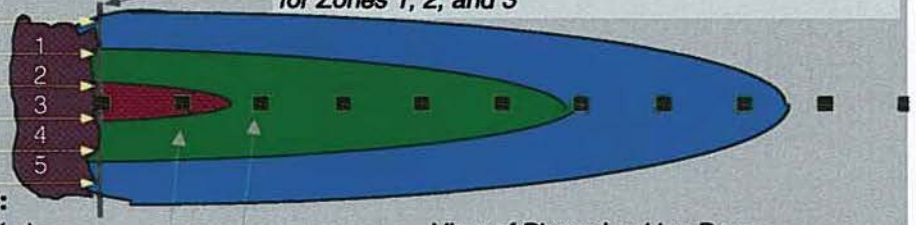
Width* (ft)	Conc. (mg/L)*
90	0.5
65	9.5
230	15
65	9.5
90	0.5

Source Halflife (see Help):

90	90	(yr)
Inst. React. ↑	↑ 1st Order	

Soluble Mass 5000 (Kg)
In Source Soil porewater

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3



View of Plume Looking Down

Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

7. FIELD DATA FOR COMPARISON

Concentration (mg/L)	12.1	10.5	3.4								
Dist. from Source (ft)	0	100	200	300	400	500	600	700	800	900	1000

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN — **View Output**

RUN ARRAY — **View Output**

Help | Recalculate

Paste Example Dataset

Restore Formulas for Vs,

CALIBRATION RUN 7

LOWER PLUME DISSOLVED CHROMIUM CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

TYPE OF MODEL	Distance from Source (ft) 0	100	200	300	400	500	600	700	800	900	1000
No Degradation	11.972	12.029	12.085	12.131	12.158	12.166	12.157	12.135	12.102	12.061	12.014
1st Order Decay	11.972	8.359	5.836	4.071	2.835	1.971	1.369	0.949	0.658	0.456	0.315
Inst. Reaction	11.972	12.029	12.085	12.131	12.158	12.166	12.157	12.135	12.102	12.061	12.014
Field Data from Site	12.100	10.500	3.400								

Calculate

Time: 30 Years

Return to

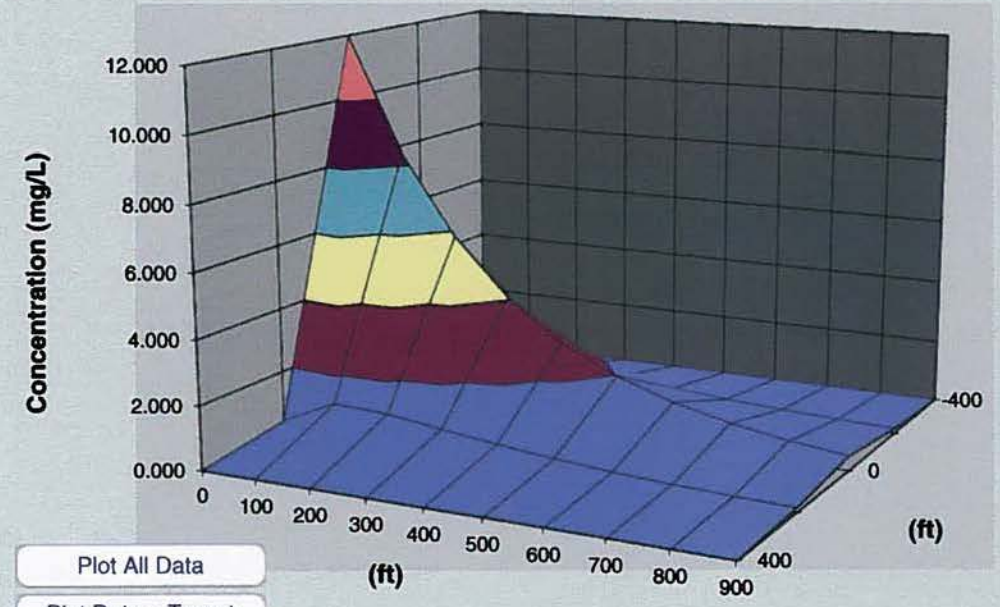
Recalculate This

CALIBRATION RUN 7 - LOWER PLUME DISSOLVED CHROMIUM CONCENTRATIONS IN PLUME (mg/L at Z=0)

Transverse Distance (ft) ↓ / Distance from Source (ft) →	0	100	200	300	400	500	600	700	800	900	1000
400	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001
200	0.399	1.197	1.114	0.887	0.674	0.501	0.368	0.267	0.193	0.139	0.099
0	11.972	8.359	5.836	4.071	2.835	1.971	1.369	0.949	0.658	0.456	0.315
-200	0.399	1.197	1.114	0.887	0.674	0.501	0.368	0.267	0.193	0.139	0.099
-400	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001
MASS FLUX (mg/day)	1.0E+5	4.6E+4	3.5E+4	2.5E+4	1.8E+4	1.3E+4	9.1E+3	6.4E+3	4.5E+3	3.2E+3	2.2E+3

Model to Display: No Degradation | 1st Order Decay | Instantaneous

Time: 30 Years Target Level: 0.100 mg/L Displayed Model: 1st Order Decay



Plot All Data

Plot Data > Target

Plume and Source Masses (Order-of-Magnitude Accuracy)

Plume Mass if No Biodegradation: Can't Calc. (Kg)

- Actual Plume Mass: Can't Calc. (Kg)

= Plume Mass Removed by Biodeg: - (Kg)

Change in Electron Acceptor/Byproduct Masses:

Oxygen	Nitrate	Iron II	Sulfate	Methane	
na	na	na	na	na	(Kg)

Contam. Mass in Source (t=0 Years): 5000.0 (Kg)

Contam. Mass in Source Now (t=30Years): 3990.6 (Kg)

Current Volume of Groundwater in Plume: Can't Calc. (ac-ft)

Flowrate of Water Through Source Zone: Can't Calc. (ac-ft/yr)

Mass HELP

Recalculat

ATTACHMENT 4
BIOSCREEN OUTPUT
SIMULATIONS TO EVALUATE MNA FOR POST-CPS INJECTION CHROMIUM CONCENTRATIONS IN THE FARM PARCEL TREATMENT AREA

BIOSCREEN Natural Attenuation Decision Support System

Air Force Center for Environmental Excellence — *Version 1.4*

Cal Run 4a Input Upper Plume Shield Alloy 12.5% Mass, Max. 0.75 ppm Cr Concentration - year 2

Upper Cr Plume
Shield Alloy
Run Name

Data Input Instructions:

115 or 0.02

1. Enter value directly....or
2. Calculate by filling in grey cells below. (To restore formulas, hit button below).

Variable* — Data used directly in model.

20 — Value calculated by model. (Don't enter any data).

1. HYDROGEOLOGY

Seepage Velocity*	Vs	521.8	(ft/yr)
or		↑ or	
Hydraulic Conductivity	K	8.9E-02	(cm/sec)
Hydraulic Gradient	i	0.0017	(ft/ft)
Porosity	n	0.3	(-)

2. DISPERSION

Longitudinal Dispersivity*	alpha x	24.5	(ft)
Transverse Dispersivity*	alpha y	2.4	(ft)
Vertical Dispersivity*	alpha z	0.0	(ft)
or		↑ or	
Estimated Plume Length	Lp	1000	(ft)

3. ADSORPTION

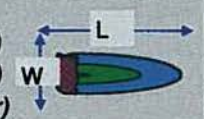
Retardation Factor*	R	1.0	(-)
or		↑ or	
Soil Bulk Density	rho	1.7	(kg/l)
Partition Coefficient	Koc	38	(L/kg)
FractionOrganicCarbon	foc	5.7E-5	(-)

4. GEOCHEMICAL ATTENUATION

1st Order Bulk Att Factor*	lambda	1.8E+0	(per yr)
or		↑ or	
Solute Half-Life	t-half	0.38	(year)
or Instantaneous Reaction Model			
Delta Oxygen*	DO	0	(mg/L)
Delta Nitrate*	NO3	0	(mg/L)
Observed Ferrous Iron*	Fe2+	0	(mg/L)
Delta Sulfate*	SO4	0	(mg/L)
Observed Methane*	CH4	0	(mg/L)

5. GENERAL

Modeled Area Length*	1400	(ft)
Modeled Area Width*	1000	(ft)
Simulation Time*	2	(yr)



6. SOURCE DATA

Source Thickness in Sat.Zone* 8 (ft)

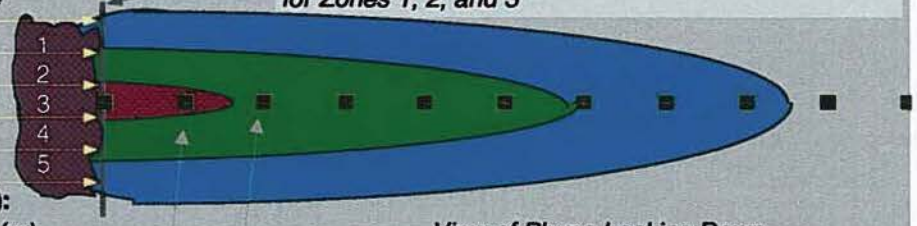
Source Zones:

Width* (ft)	Conc. (mg/L)*
40	0.3
58	0.75
115	0.75
58	0.75
40	0.3

Source Halflife (see Help):

40	40	(yr)
Inst. React. ↑	↑ 1st Order	
Soluble Mass	438	(Kg)
In Source NAPL, Soil		

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3



View of Plume Looking Down

Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

7. FIELD DATA FOR COMPARISON

Dist. from Source (ft)	0	140	280	420	560	700	840	980	1120	1260	1400
Concentration (mg/L)											

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN — **View Output**

RUN ARRAY — **View Output**

Help — Recalculate

Paste Example Dataset

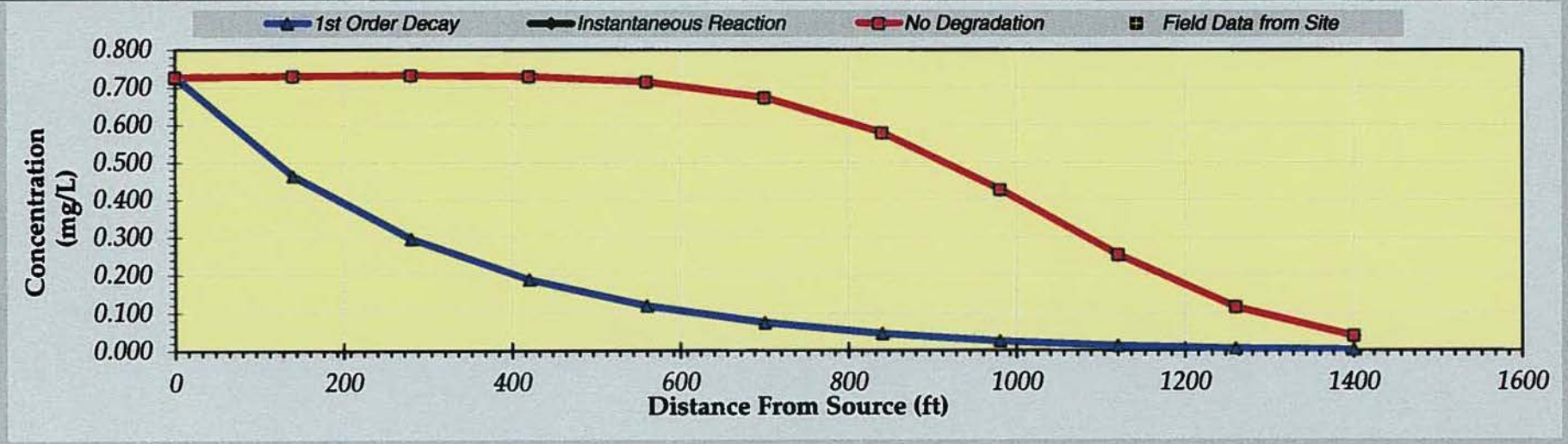
Restore Formulas for Vs,

CAL RUN 4A, 0.75 ppm Cr

UPPER PLUME DISSOLVED CHROMIUM CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

12.5% Mass

TYPE OF MODEL	Distance from Source (ft) 0	140	280	420	560	700	840	980	1120	1260	1400
No Degradation	0.726	0.730	0.732	0.729	0.714	0.672	0.578	0.426	0.252	0.114	0.038
1st Order Decay	0.726	0.464	0.296	0.188	0.118	0.074	0.044	0.025	0.012	0.005	0.001
Inst. Reaction	0.726	0.730	0.732	0.729	0.714	0.672	0.578	0.426	0.252	0.114	0.038
Field Data from Site											



Calculate

Time: 2 Years

Return to

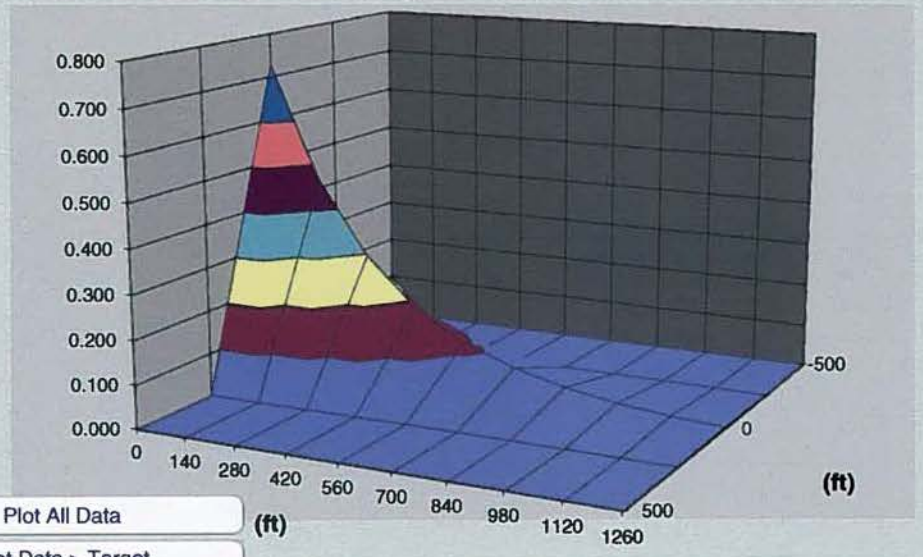
Recalculate This

CAL RUN 4A INPUT, 12.5%M, 0.75 PPM CR DISSOLVED CHROMIUM CONCENTRATIONS IN UPPER PLUME (mg/L at Z=0)

Transverse Distance (ft) ↓ / Distance from Source (ft) →	0	140	280	420	560	700	840	980	1120	1260	1400
500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
250	0.000	0.000	0.001	0.002	0.002	0.002	0.002	0.001	0.001	0.000	0.000
0	0.726	0.464	0.296	0.188	0.118	0.074	0.044	0.025	0.012	0.005	0.001
-250	0.000	0.000	0.001	0.002	0.002	0.002	0.002	0.001	0.001	0.000	0.000
-500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MASS FLUX (mg/day)	1.9E+4	1.1E+4	7.2E+3	4.6E+3	3.0E+3	1.9E+3	1.2E+3	6.6E+2	3.3E+2	1.3E+2	4.1E+1

Model to Display: *No Degradation* | *1st Order Decay* | *Instantaneous*

Time: **2 Years** Target Level: **0.100** mg/L Displayed Model: **1st Order Decay**



Plot All Data

Plot Data > Target

Plume and Source Masses (Order-of-Magnitude Accuracy)

Plume Mass if No Biodegradation	13.8	(Kg)
- Actual Plume Mass	4.0	(Kg)
= Plume Mass Removed by Biodeg	9.8	(Kg) (71 %)

Change in Electron Acceptor/Byproduct Masses:

Oxygen	*Nitrate*	*Iron II*	*Sulfate*	*Methane*	
na	na	na	na	na	(Kg)

Contam. Mass in Source (t=0 Years)	438.0	(Kg)
Contam. Mass in Source Now (t=2Years)	424.2	(Kg)
Current Volume of Groundwater in Plume	17.4	(ac-ft)
Flowrate of Water Through Source Zone	8.941	(ac-ft/yr)

Mass HELP

Recalculat

BIOSCREEN Natural Attenuation Decision Support System

Air Force Center for Environmental Excellence — *Version 1.4*

Calibration Run 4a r1 Input Upper Plume Shield Alloy, 12.5% Mass, Maximum 0.75 PPM Cr - 2 year

Upper Cr Plume
Shield Alloy
Run Name

Data Input Instructions:

115
or
0.02

1. Enter value directly....or
2. Calculate by filling in grey cells below. (To restore formulas, hit button below).

Variable* — Data used directly in model.
20 — Value calculated by model. (Don't enter any data).

1. HYDROGEOLOGY

Seepage Velocity*	Vs	782.7	(ft/yr)
or		or	
Hydraulic Conductivity	K	8.9E-02	(cm/sec)
Hydraulic Gradient	i	0.0017	(ft/ft)
Porosity	n	0.2	(-)

2. DISPERSION

Longitudinal Dispersivity*	alpha x	24.5	(ft)
Transverse Dispersivity*	alpha y	2.4	(ft)
Vertical Dispersivity*	alpha z	0.0	(ft)
or		or	
Estimated Plume Length	Lp	1000	(ft)

3. ADSORPTION

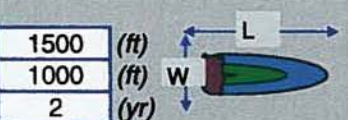
Retardation Factor*	R	1.0	(-)
or		or	
Soil Bulk Density	rho	1.7	(kg/l)
Partition Coefficient	Koc	38	(L/kg)
FractionOrganicCarbon	foc	5.7E-5	(-)

4. GEOCHEMICAL ATTENUATION

1st Order Bulk Att factor*	lambda	1.8E+0	(per yr)
or		or	
Solute Half-Life	t-half	0.38	(year)
or Instantaneous Reaction Model			
Delta Oxygen*	DO	0	(mg/L)
Delta Nitrate*	NO3	0	(mg/L)
Observed Ferrous Iron*	Fe2+	0	(mg/L)
Delta Sulfate*	SO4	0	(mg/L)
Observed Methane*	CH4	0	(mg/L)

5. GENERAL

Modeled Area Length*	1500	(ft)
Modeled Area Width*	1000	(ft)
Simulation Time*	2	(yr)



6. SOURCE DATA

Source Thickness in Sat.Zone* 7 (ft)

Source Zones:

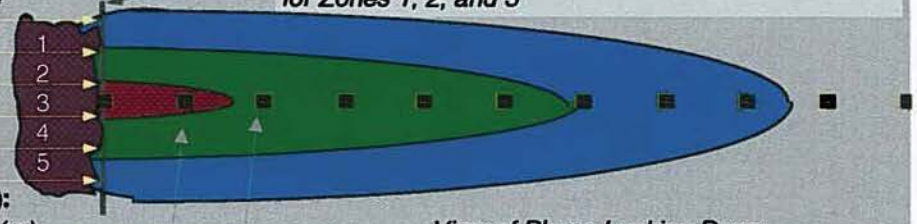
Width* (ft)	Conc. (mg/L)*
40	0.3
58	0.75
115	0.75
58	0.75
40	0.3

Source Halflife (see Help):

50	50	(yr)
Inst. React.	1st Order	
Soluble Mass	438	(Kg)

In Source NAPL, Soil

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3



View of Plume Looking Down

Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

7. FIELD DATA FOR COMPARISON

Dist. from Source (ft)	Concentration (mg/L)
0	
150	
300	
450	
600	
750	
900	
1050	
1200	
1350	
1500	

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN — View Output

RUN ARRAY — View Output

Help

Recalculate

Paste Example Dataset

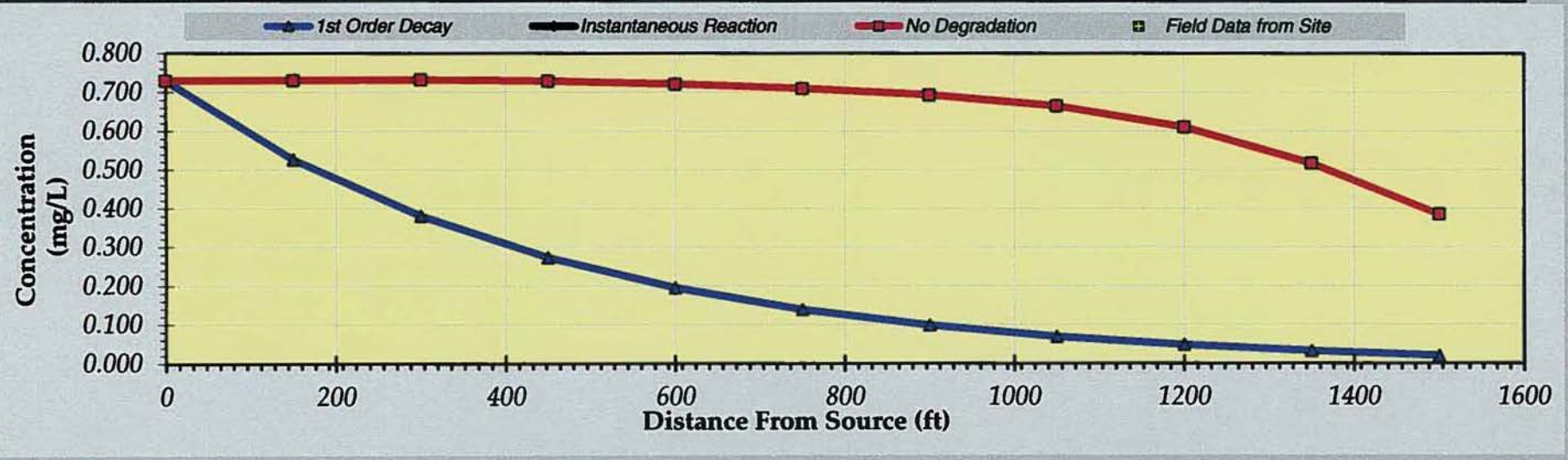
Restore Formulas for Vs,

CAL RUN 4A r1 0.75 ppm

UPPER PLUME DISSOLVED CHROMIUM CONCENTRATION ALONG CENTERLINE (mg/L at Z=0)

12.5 % Mass

TYPE OF MODEL	Distance from Source (ft) 0	150	300	450	600	750	900	1050	1200	1350	1500
No Degradation	0.729	0.731	0.732	0.729	0.721	0.710	0.693	0.665	0.611	0.517	0.385
1st Order Decay	0.729	0.527	0.380	0.273	0.195	0.138	0.098	0.069	0.048	0.032	0.020
Inst. Reaction	0.729	0.731	0.732	0.729	0.721	0.710	0.693	0.665	0.611	0.517	0.385
Field Data from Site											



Calculate

Time: 2 Years

Return to

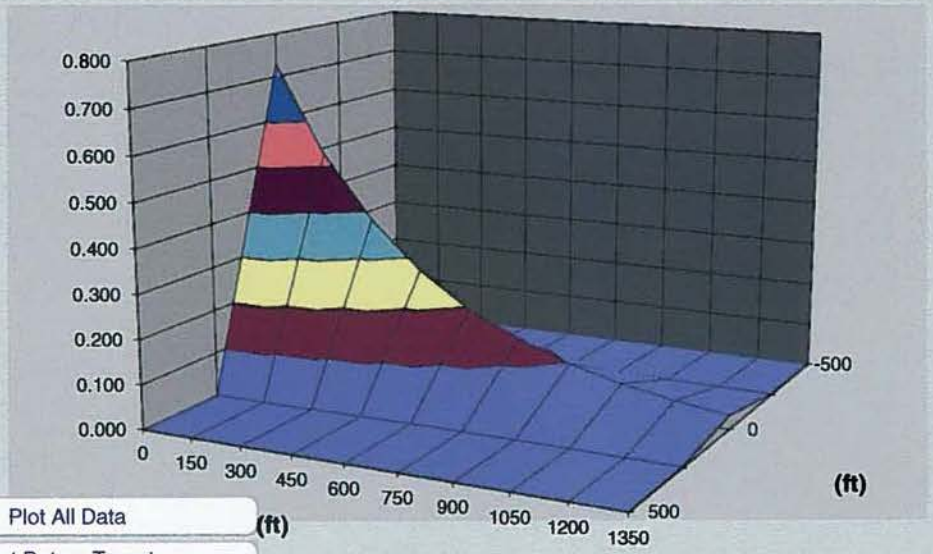
Recalculate This

CAL RUN 4A R1 INPUT, 12.5%m, 0.75 PPM CR- UPPER PLUME DISSOLVED CHROMIUM CONCENTRATIONS IN PLUME (mg/L at Z=0)

Transverse Distance (ft) ↓ / Distance from Source (ft)	0	150	300	450	600	750	900	1050	1200	1350	1500
500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
250	0.000	0.000	0.001	0.003	0.004	0.005	0.005	0.004	0.004	0.003	0.002
0	0.729	0.527	0.380	0.273	0.195	0.138	0.098	0.069	0.048	0.032	0.020
-250	0.000	0.000	0.001	0.003	0.004	0.005	0.005	0.004	0.004	0.003	0.002
-500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MASS FLUX (mg/day)	1.7E+4	1.1E+4	8.1E+3	5.9E+3	4.3E+3	3.1E+3	2.3E+3	1.6E+3	1.2E+3	8.0E+2	5.0E+2

Model to Display: *No Degradation* | *1st Order Decay* | *Instantaneous*

Time: **2 Years** Target Level: **0.100** mg/L Displayed Model: **1st Order Decay**



Plot All Data

Plot Data > Target

Plume and Source Masses (Order-of-Magnitude Accuracy)

Plume Mass if No Biodegradation	12.1	*(Kg)*
- Actual Plume Mass	3.6	*(Kg)*
= Plume Mass Removed by Biodeg	8.5	*(Kg)* (70 %)

Change in Electron Acceptor/Byproduct Masses:

Oxygen	*Nitrate*	*Iron II*	*Sulfate*	*Methane*	
na	na	na	na	na	*(Kg)*

Contam. Mass in Source (t=0 Years)	438.0	*(Kg)*
Contam. Mass in Source Now (t=2Years)	425.9	*(Kg)*
Current Volume of Groundwater in Plume	13.3	*(ac-ft)*
Flowrate of Water Through Source Zone	7.824	*(ac-ft/yr)*

Mass HELP

Recalculat

BIOSCREEN Natural Attenuation Decision Support System

Air Force Center for Environmental Excellence — *Version 1.4*

Calibration Run 5a r1 Input Upper Plume Shield Alloy 12.5% Mass, Max 0.75 ppm Cr - year 2

Upper Cr Plume
Shield Alloy
Run Name

Data Input Instructions:

1. Enter value directly....or
2. Calculate by filling in grey cells below. (To restore formulas, hit button below).

Variable* → Data used directly in model.
Value calculated by model. (Don't enter any data).

1. HYDROGEOLOGY

Seepage Velocity*	Vs	452.3	(ft/yr)
or		or	
Hydraulic Conductivity	K	9.0E-02	(cm/sec)
Hydraulic Gradient	i	0.0017	(ft/ft)
Porosity	n	0.35	(-)

2. DISPERSION

Longitudinal Dispersivity*	alpha x	28.9	(ft)
Transverse Dispersivity*	alpha y	2.9	(ft)
Vertical Dispersivity*	alpha z	0.0	(ft)
or		or	
Estimated Plume Length	Lp	1500	(ft)

3. ADSORPTION

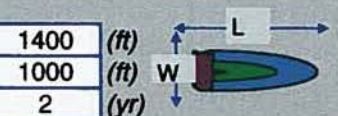
Retardation Factor*	R	1.0	(-)
or		or	
Soil Bulk Density	rho	1.7	(kg/l)
Partition Coefficient	Koc	38	(L/kg)
FractionOrganicCarbon	foc	5.7E-5	(-)

4. GEOCHEMICAL ATTENUATION

1st Order Bulk Att Factor*	lambda	1.7E+0	(per yr)
or		or	
Solute Half-Life	t-half	0.40	(year)
or Instantaneous Reaction Model			
Delta Oxygen*	DO	0	(mg/L)
Delta Nitrate*	NO3	0	(mg/L)
Observed Ferrous Iron*	Fe2+	0	(mg/L)
Delta Sulfate*	SO4	0	(mg/L)
Observed Methane*	CH4	0	(mg/L)

5. GENERAL

Modeled Area Length*	1400	(ft)
Modeled Area Width*	1000	(ft)
Simulation Time*	2	(yr)



115 (or 0.02)

6. SOURCE DATA

Source Thickness in Sat.Zone* 9 (ft)

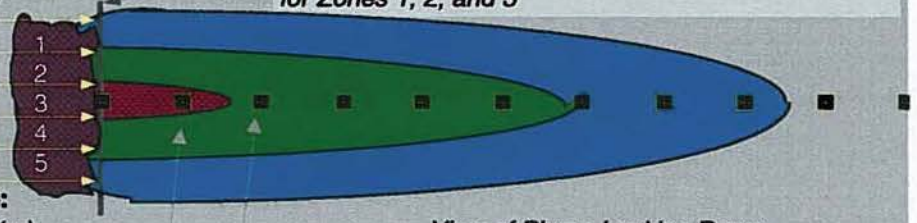
Source Zones:

Width* (ft)	Conc. (mg/L)*
40	0.3
58	0.75
115	0.75
58	0.75
40	0.3

Source Halflife (see Help):

40	40	(yr)
Inst. React.	1st Order	
Soluble Mass	475	(Kg)
In Source NAPL, Soil		

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3



View of Plume Looking Down

Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

7. FIELD DATA FOR COMPARISON

Dist. from Source (ft)	0	140	280	420	560	700	840	980	1120	1260	1400
Concentration (mg/L)											

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN — View Output

RUN ARRAY — View Output

Help

Recalculate

Paste Example Dataset

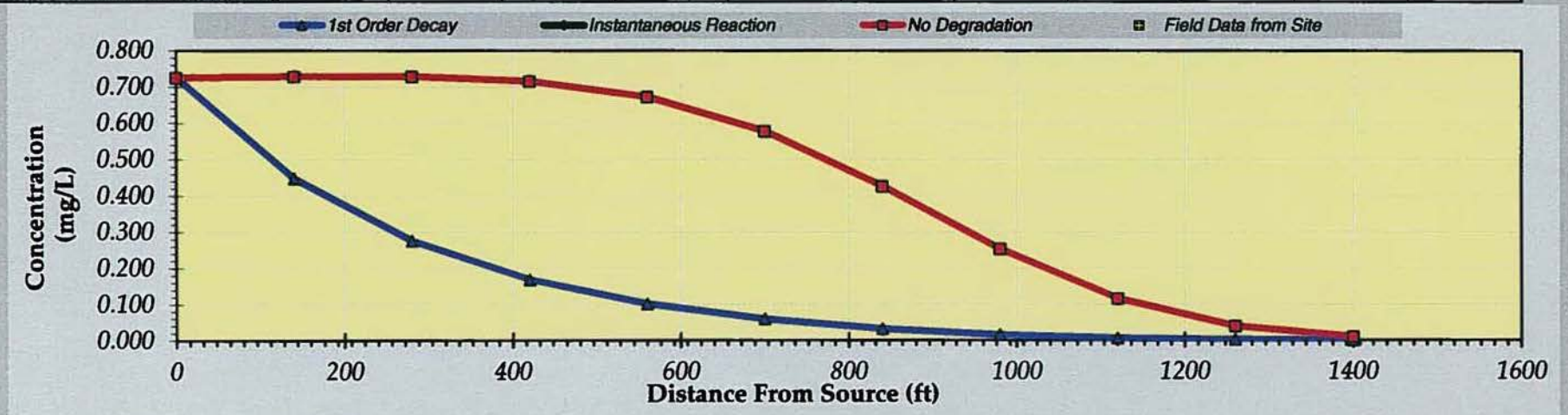
Restore Formulas for Vs,

CAL RUN 5AR1, 0.75 ppm Cr

UPPER PLUME DISSOLVED CHROMIUM CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

12.5% Mass

TYPE OF MODEL	Distance from Source (ft) 0	140	280	420	560	700	840	980	1120	1260	1400
No Degradation	0.725	0.729	0.729	0.715	0.672	0.578	0.426	0.253	0.115	0.039	0.010
1st Order Decay	0.725	0.448	0.276	0.168	0.101	0.059	0.032	0.015	0.006	0.002	0.000
Inst. Reaction	0.725	0.729	0.729	0.715	0.672	0.578	0.426	0.253	0.115	0.039	0.010
Field Data from Site											



Calculate

Time: 2 Years

Return to

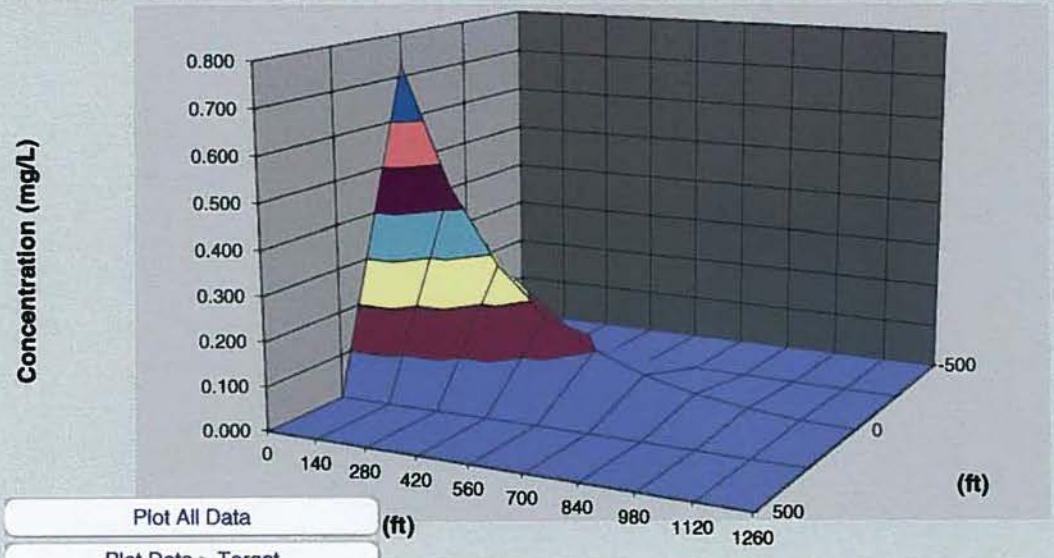
Recalculate This

CAL RUN 5A R1 12.5%m, 0.75 PPM CR UPPER PLUME DISSOLVED CHROMIUM CONCENTRATIONS IN PLUME (mg/L at Z=0)

Transverse Distance (ft) ↓ / Distance from Source (ft) →	0	140	280	420	560	700	840	980	1120	1260	1400
500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
250	0.000	0.000	0.001	0.002	0.003	0.002	0.002	0.001	0.001	0.000	0.000
0	0.725	0.448	0.276	0.168	0.101	0.059	0.032	0.015	0.006	0.002	0.000
-250	0.000	0.000	0.001	0.002	0.003	0.002	0.002	0.001	0.001	0.000	0.000
-500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MASS FLUX (mg/day)	2.2E+4	1.2E+4	7.7E+3	4.8E+3	2.9E+3	1.8E+3	9.9E+2	4.8E+2	1.9E+2	6.0E+1	1.4E+1

Model to Display: *No Degradation* | *1st Order Decay* | *Instantaneous*

Time: **2 Years** Target Level: **0.100** mg/L Displayed Model: **1st Order Decay**



Plot All Data

Plot Data > Target

Plume and Source Masses (Order-of-Magnitude Accuracy)

Plume Mass if No Biodegradation	15.6	(Kg)
- Actual Plume Mass	4.8	(Kg)
= Plume Mass Removed by Biodeg	**10.8**	(Kg) (69 %)

Change in Electron Acceptor/Byproduct Masses:

Oxygen	*Nitrate*	*Iron II*	*Sulfate*	*Methane*	
na	na	na	na	na	(Kg)

Contam. Mass in Source (t=0 Years)	475.0	(Kg)
Contam. Mass in Source Now (t=2Years)	459.4	(Kg)
Current Volume of Groundwater in Plume	22.8	(ac-ft)
Flowrate of Water Through Source Zone	10.172	(ac-ft/yr)

Mass HELP

Recalculat

BIOSCREEN Natural Attenuation Decision Support System

Air Force Center for Environmental Excellence — *Version 1.4*

Run 5 Cal parameters for Lower Aquifer, 12.5 percent orginal mass, max conc. 1.25 ppm, 5 yr

Lower Cr Plume
Shield Alloy
Run Name

Data Input Instructions:

115
↑ or
0.02

1. Enter value directly....or
2. Calculate by filling in grey cells below. (To restore formulas, hit button below).

Variable* → Data used directly in model.
20 → Value calculated by model. (Don't enter any data).

1. HYDROGEOLOGY

Seepage Velocity*	Vs	298.0	(ft/yr)
or		↑ or	
Hydraulic Conductivity	K	3.6E-02	(cm/sec)
Hydraulic Gradient	i	0.0016	(ft/ft)
Porosity	n	0.2	(-)

2. DISPERSION

Longitudinal Dispersivity*	alpha x	24.5	(ft)
Transverse Dispersivity*	alpha y	2.4	(ft)
Vertical Dispersivity*	alpha z	0.0	(ft)
or		↑ or	
Estimated Plume Length	Lp	1000	(ft)

3. ADSORPTION

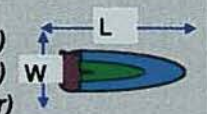
Retardation Factor*	R	1.3	(-)
or		↑ or	
Soil Bulk Density	rho	1.7	(kg/l)
Partition Coefficient	Koc	1000	(L/kg)
FractionOrganicCarbon	foc	5.7E-6	(-)

4. BIODEGRADATION

1st Order Decay Coeff*	lambda	8.3E-1	(per yr)
or		↑ or	
Solute Half-Life	t-half	0.83	(year)
or Instantaneous Reaction Model			
Delta Oxygen*	DO	0	(mg/L)
Delta Nitrate*	NO3	0	(mg/L)
Observed Ferrous Iron*	Fe2+	0	(mg/L)
Delta Sulfate*	SO4	0	(mg/L)
Observed Methane*	CH4	0	(mg/L)

5. GENERAL

Modeled Area Length*	1500	(ft)
Modeled Area Width*	1500	(ft)
Simulation Time*	5	(yr)



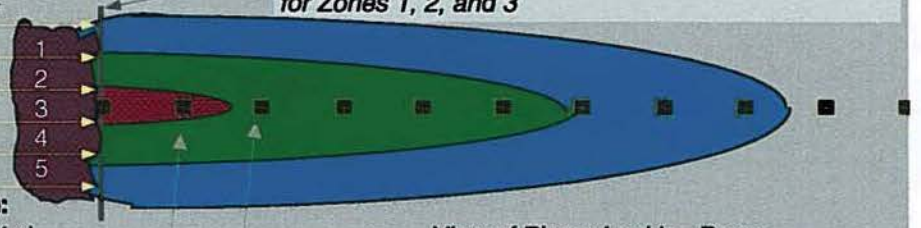
6. SOURCE DATA

Source Thickness in Sat.Zone* 7 (ft)

Source Zones:

Width* (ft)	Conc. (mg/L)*
90	0.5
65	1.25
230	1.25
65	1.25
90	0.5

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3



View of Plume Looking Down

Source Halflife (see Help):

100	100 (yr)
Inst. React. ↑	↑ 1st Order

Soluble Mass 1250 (Kg)
In Source Soil porewater

Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

7. FIELD DATA FOR COMPARISON

Dist. from Source (ft)	Concentration (mg/L)
0	
150	
300	
450	
600	
750	
900	
1050	
1200	
1350	
1500	

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN — **View Output**

RUN ARRAY — **View Output**

Help | Recalculate

Paste Example Dataset

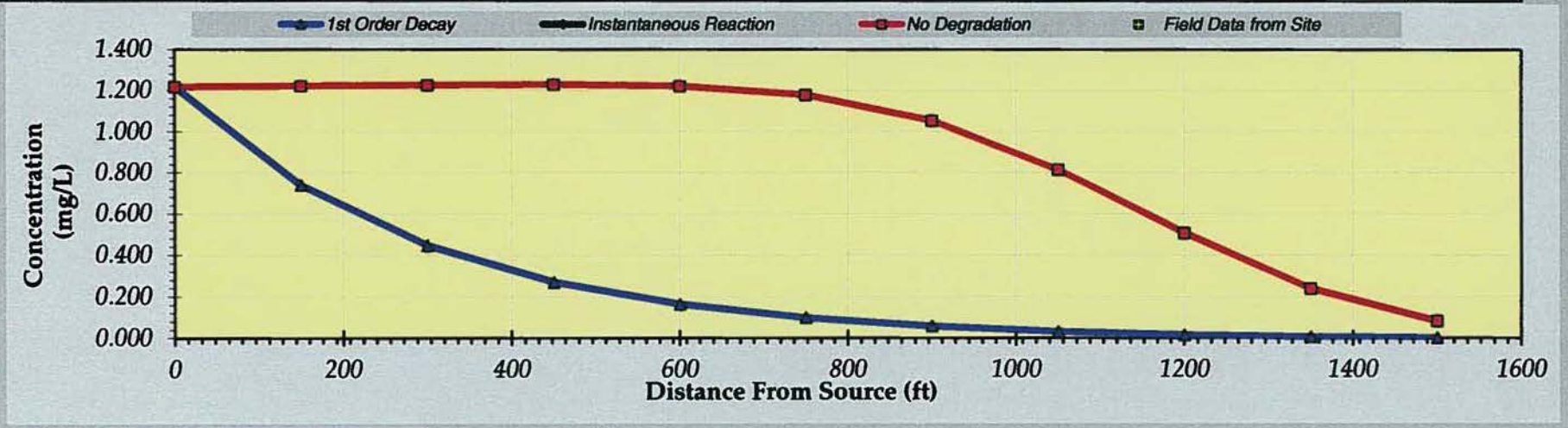
Restore Formulas for Vs,

CAL RUN 5 INPUT 1.25 PPM

LOWER PLUME DISSOLVED CHROMIUM CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

12.5% MASS

TYPE OF MODEL	Distance from Source (ft) 0	150	300	450	600	750	900	1050	1200	1350	1500
No Degradation	1.219	1.223	1.226	1.229	1.221	1.178	1.053	0.814	0.507	0.239	0.083
1st Order Decay	1.219	0.738	0.447	0.271	0.164	0.098	0.058	0.032	0.016	0.006	0.002
Inst. Reaction	1.219	1.223	1.226	1.229	1.221	1.178	1.053	0.814	0.507	0.239	0.083
Field Data from Site											



Calculate

Time: 5 Years

Return to

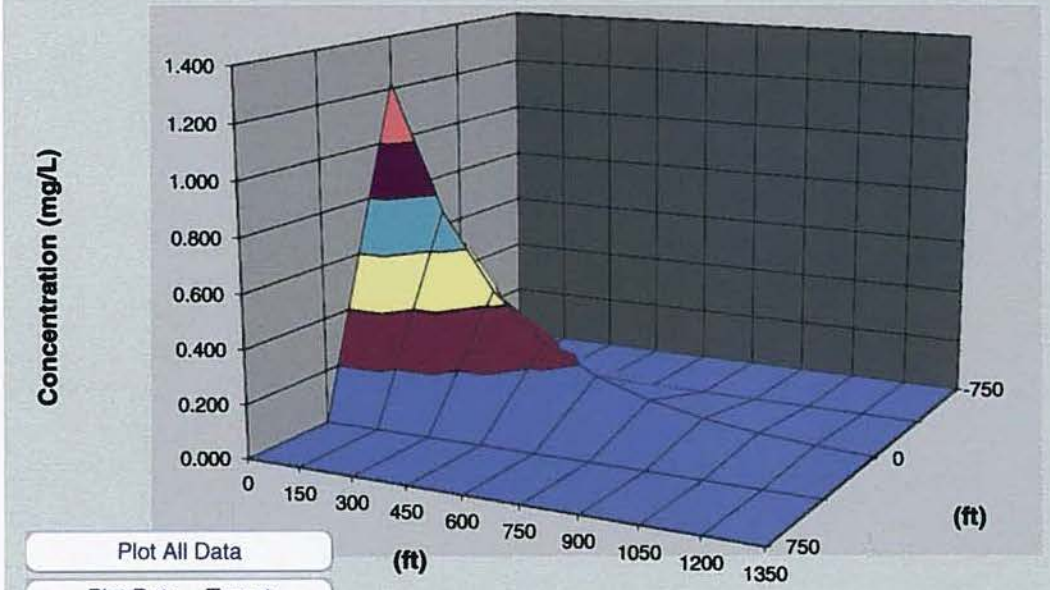
Recalculate This

CAL RUN 5 INPUT 12.5% MASS 1.25 PPM DISSOLVED CHROMIUM CONCENTRATIONS IN LOWERPLUME (mg/L at Z=0)

Transverse Distance (ft) ↓	Distance from Source (ft) 0	150	300	450	600	750	900	1050	1200	1350	1500
750	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
375	0.000	0.000	0.001	0.001	0.002	0.002	0.001	0.001	0.001	0.000	0.000
0	1.219	0.738	0.447	0.271	0.164	0.098	0.058	0.032	0.016	0.006	0.002
-375	0.000	0.000	0.001	0.001	0.002	0.002	0.001	0.001	0.001	0.000	0.000
-750	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MASS FLUX (mg/day)	1.7E+4	9.0E+3	5.4E+3	3.3E+3	2.0E+3	1.2E+3	7.4E+2	4.1E+2	2.0E+2	8.2E+1	2.6E+1

Model to Display: *No Degradation* | *1st Order Decay* | *Instantaneous*

Time: **5 Years** Target Level: **0.100** mg/L Displayed Model: **1st Order Decay**



Plot All Data

Plot Data > Target

Plume and Source Masses (Order-of-Magnitude Accuracy)

Plume Mass if No Biodegradation	31.5	(Kg)
- Actual Plume Mass	6.2	(Kg)
= Plume Mass Removed by Biodeg	25.3	(Kg) (80 %)

Change in Electron Acceptor/Byproduct Masses:

Oxygen	*Nitrate*	*Iron II*	*Sulfate*	*Methane*	
na	na	na	na	na	(Kg)

Contam. Mass in Source (t=0 Years)	1250.0	(Kg)
Contam. Mass in Source Now (t=5Years)	1218.5	(Kg)
Current Volume of Groundwater in Plume	18.1	(ac-ft)
Flowrate of Water Through Source Zone	5.172	(ac-ft/yr)

Mass HELP

Recalculat

BIOSCREEN Natural Attenuation Decision Support System

Air Force Center for Environmental Excellence *Version 1.4*

Run 6 Cal Input Parameters for Lower Aquifer, 12.5%Mass, 1.25 ppm Chromium - 5 year

Lower Cr Plume
Shield Alloy
Run Name

Data Input Instructions:

115 or 0.02

1. Enter value directly....or
2. Calculate by filling in grey cells below. (To restore formulas, hit button below).

Variable* — Data used directly in model.

20 — Value calculated by model. (Don't enter any data).

1. HYDROGEOLOGY

Seepage Velocity*	Vs	298.0	(ft/yr)
or		or	
Hydraulic Conductivity	K	3.6E-02	(cm/sec)
Hydraulic Gradient	i	0.0016	(ft/ft)
Porosity	n	0.2	(-)

2. DISPERSION

Longitudinal Dispersivity*	alpha x	24.5	(ft)
Transverse Dispersivity*	alpha y	2.4	(ft)
Vertical Dispersivity*	alpha z	0.0	(ft)
or		or	
Estimated Plume Length	Lp	1000	(ft)

3. ADSORPTION

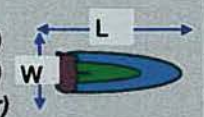
Retardation Factor*	R	1.0	(-)
or		or	
Soil Bulk Density	rho	1.7	(kg/l)
Partition Coefficient	Koc	1000	(L/kg)
FractionOrganicCarbon	foc	5.7E-6	(-)

4. BIODEGRADATION

1st Order Decay Coeff*	lambda	1.0E+0	(per yr)
or		or	
Solute Half-Life	t-half	0.69	(year)
or Instantaneous Reaction Model			
Delta Oxygen*	DO	0	(mg/L)
Delta Nitrate*	NO3	0	(mg/L)
Observed Ferrous Iron*	Fe2+	0	(mg/L)
Delta Sulfate*	SO4	0	(mg/L)
Observed Methane*	CH4	0	(mg/L)

5. GENERAL

Modeled Area Length*	1500	(ft)
Modeled Area Width*	1500	(ft)
Simulation Time*	5	(yr)



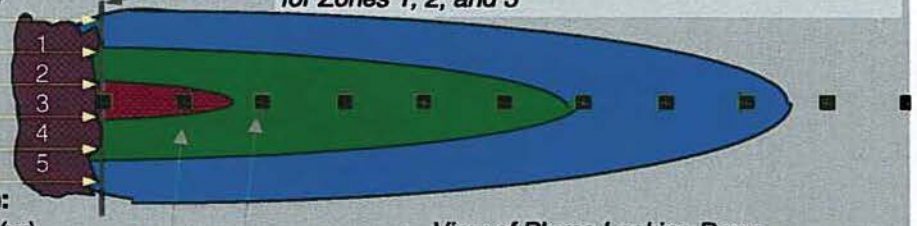
6. SOURCE DATA

Source Thickness in Sat.Zone* 7 (ft)

Source Zones:

Width* (ft)	Conc. (mg/L)*	
90	0.5	1
65	1.25	2
230	1.25	3
65	1.25	4
90	0.5	5

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3



View of Plume Looking Down

Source Halflife (see Help):

100 (Inst. React.) | 100 (1st Order) (yr)

Soluble Mass In Source Soil porewater 1125 (Kg)

Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

7. FIELD DATA FOR COMPARISON

Dist. from Source (ft)	Concentration (mg/L)
0	
150	
300	
450	
600	
750	
900	
1050	
1200	
1350	
1500	

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN — **View Output**

RUN ARRAY — **View Output**

Help | Recalculate

Paste Example Dataset

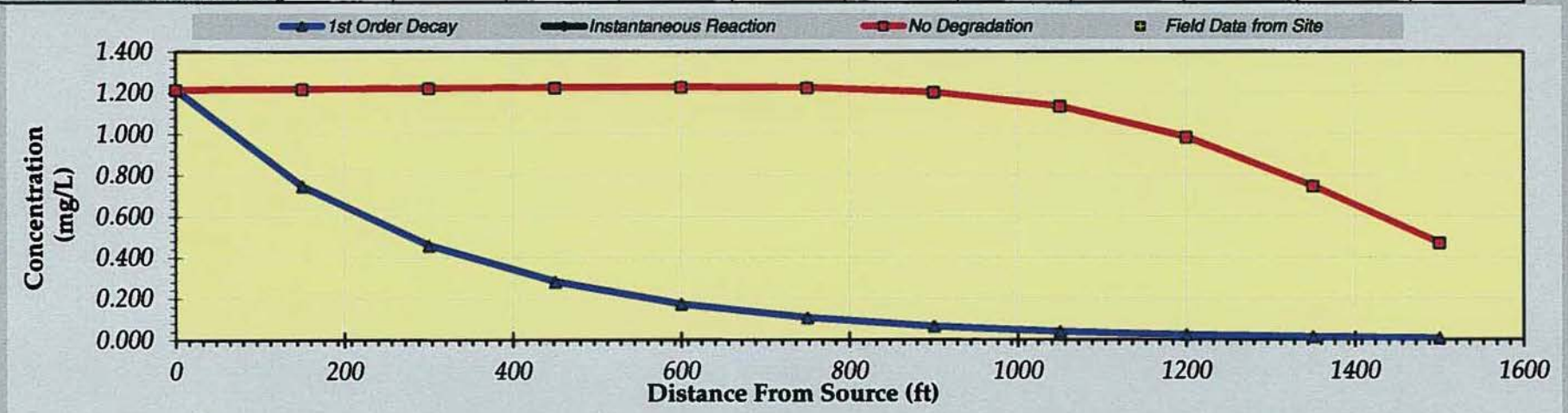
Restore Formulas for Vs,

CAL RUN 6 Input Cr 1.25ppm

LOWER PLUME DISSOLVED CHROMIUM CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

12.5% Mass

TYPE OF MODEL	Distance from Source (ft) 0	150	300	450	600	750	900	1050	1200	1350	1500
No Degradation	1.215	1.219	1.222	1.226	1.228	1.224	1.202	1.133	0.983	0.744	0.467
1st Order Decay	1.215	0.746	0.458	0.281	0.173	0.106	0.065	0.039	0.023	0.013	0.006
Inst. Reaction	1.215	1.219	1.222	1.226	1.228	1.224	1.202	1.133	0.983	0.744	0.467
Field Data from Site											



Calculate

Time: 5 Years

Return to

Recalculate This

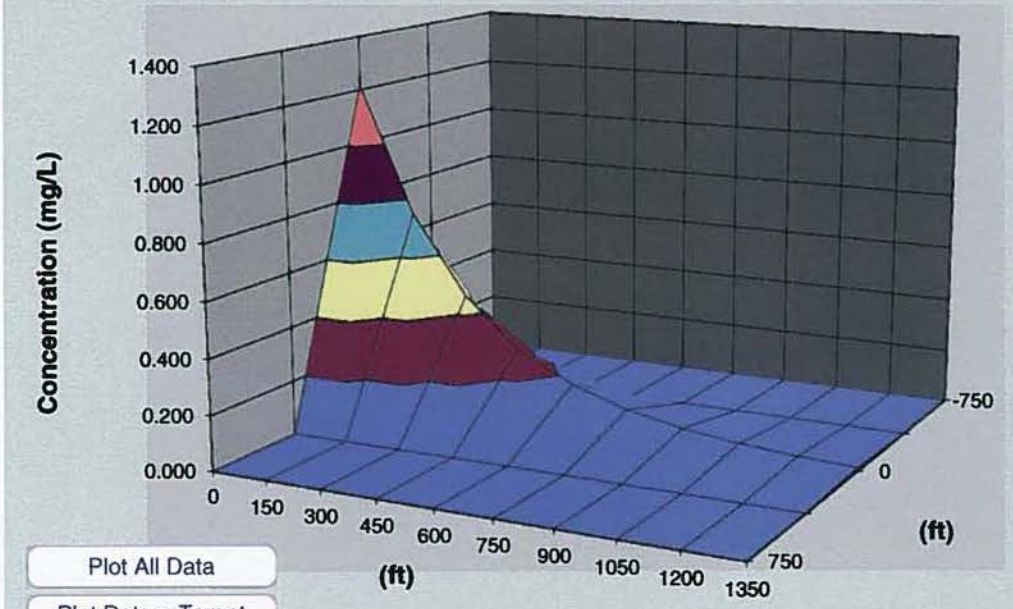
CAL RUN 6 INPUT, 12.5%M 1.25 PPM - DISSOLVED CHROMIUM CONCENTRATIONS IN PLUME (mg/L at Z=0)

Transverse Distance (ft) ↓ / Distance from Source (ft) →	0	150	300	450	600	750	900	1050	1200	1350	1500
750	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
375	0.000	0.000	0.001	0.001	0.002	0.002	0.002	0.001	0.001	0.001	0.000
0	1.215	0.746	0.458	0.281	0.173	0.106	0.065	0.039	0.023	0.013	0.006
-375	0.000	0.000	0.001	0.001	0.002	0.002	0.002	0.001	0.001	0.001	0.000
-750	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MASS FLUX (mg/day)	1.7E+4	9.0E+3	5.6E+3	3.4E+3	2.1E+3	1.3E+3	8.2E+2	5.1E+2	3.0E+2	1.7E+2	8.6E+1

Model to Display:

- No Degradation
- 1st Order Decay
- Instantaneous

Time: **5 Years** Target Level: **0.100** mg/L Displayed Model: **1st Order Decay**



Plot All Data

Plot Data > Target

Plume and Source Masses (Order-of-Magnitude Accuracy)

Plume Mass if No Biodegradation	31.4	(Kg)
- Actual Plume Mass	6.5	(Kg)
= Plume Mass Removed by Biodeg	**24.9**	(Kg) (79 %)

Change in Electron Acceptor/Byproduct Masses:

Oxygen	Nitrate	Iron II	Sulfate	Methane	
na	na	na	na	na	(Kg)

Contam. Mass in Source (t=0 Years)	1125.0	(Kg)
Contam. Mass in Source Now (t=5Years)	1093.6	(Kg)
Current Volume of Groundwater in Plume	19.9	(ac-ft)
Flowrate of Water Through Source Zone	5.172	(ac-ft/yr)

Mass HELP

Recalculat

BIOSCREEN Natural Attenuation Decision Support System

Air Force Center for Environmental Excellence — *Version 1.4*

Run 7 Cal Parameters for Lower Aquifer 12.5 % Original Mass, Max. 1.25 ppm Chromium - 7 year

Lower Cr Plume
Shield Alloy
Run Name

Data Input Instructions:

1. Enter value directly....or
2. Calculate by filling in grey cells below. (To restore formulas, hit button below).

Variable* — Data used directly in model.
Value calculated by model. (Don't enter any data).

1. HYDROGEOLOGY

Seepage Velocity*	Vs	158.9	(ft/yr)
or		*or*	
Hydraulic Conductivity	K	2.4E-02	(cm/sec)
Hydraulic Gradient	i	0.0016	(ft/ft)
Porosity	n	0.25	(-)

2. DISPERSION

Longitudinal Dispersivity*	alpha x	24.5	(ft)
Transverse Dispersivity*	alpha y	2.4	(ft)
Vertical Dispersivity*	alpha z	0.0	(ft)
or		*or*	
Estimated Plume Length	Lp	1000	(ft)

3. ADSORPTION

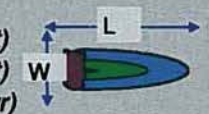
Retardation Factor*	R	1.0	(-)
or		*or*	
Soil Bulk Density	rho	1.7	(kg/l)
Partition Coefficient	Koc	1000	(L/kg)
FractionOrganicCarbon	foc	5.7E-6	(-)

4. BIODEGRADATION

1st Order Decay Coeff*	lambda	6.3E-1	(per yr)
or		*or*	
Solute Half-Life	t-half	1.10	(year)
or Instantaneous Reaction Model			
Delta Oxygen*	DO	0	(mg/L)
Delta Nitrate*	NO3	0	(mg/L)
Observed Ferrous Iron*	Fe2+	0	(mg/L)
Delta Sulfate*	SO4	0	(mg/L)
Observed Methane*	CH4	0	(mg/L)

5. GENERAL

Modeled Area Length*	1500	(ft)
Modeled Area Width*	1500	(ft)
Simulation Time*	7	(yr)



6. SOURCE DATA

Source Thickness in Sat.Zone* 7 (ft)

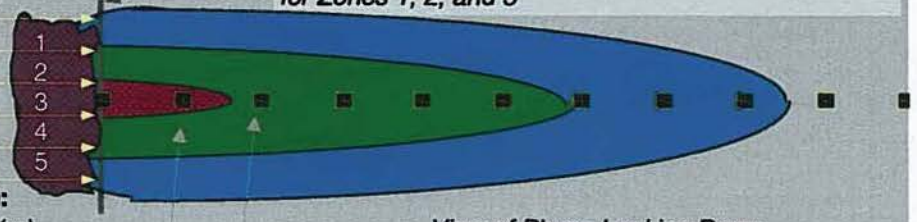
Source Zones:

Width* (ft)	Conc. (mg/L)*
90	0.5
65	1.25
230	1.25
65	1.25
90	0.5

Source Halflife (see Help):

100	100	(yr)
Inst. React.	1st Order	
Soluble Mass	625	(Kg)
In Source Soil porewater		

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3



View of Plume Looking Down

Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

7. FIELD DATA FOR COMPARISON

Dist. from Source (ft)	Concentration (mg/L)
0	
150	
300	
450	
600	
750	
900	
1050	
1200	
1350	
1500	

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN — **View Output**

RUN ARRAY — **View Output**

Help — Recalculate

Paste Example Dataset

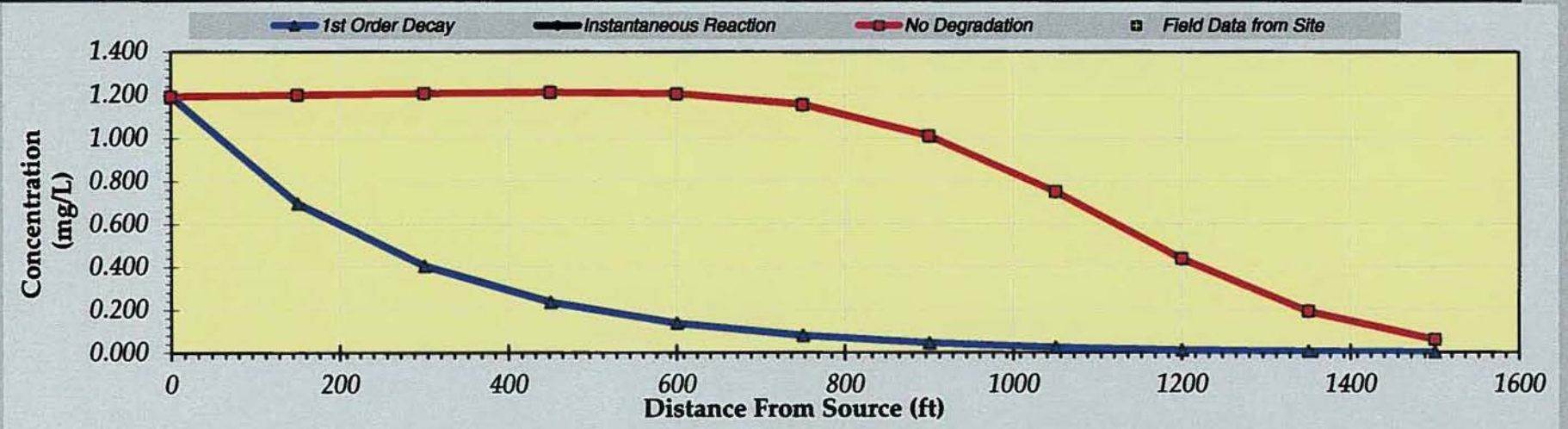
Restore Formulas for Vs,

CAL RUN 7 Input 1.25 ppm

LOWER PLUME DISSOLVED CHROMIUM CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

12.5% Mass

TYPE OF MODEL	Distance from Source (ft) 0	150	300	450	600	750	900	1050	1200	1350	1500
No Degradation	1.192	1.200	1.207	1.212	1.205	1.155	1.010	0.749	0.437	0.190	0.059
1st Order Decay	1.192	0.695	0.405	0.236	0.137	0.079	0.045	0.024	0.011	0.004	0.001
Inst. Reaction	1.192	1.200	1.207	1.212	1.205	1.155	1.010	0.749	0.437	0.190	0.059
Field Data from Site											



Calculate

Time: 7 Years

Return to

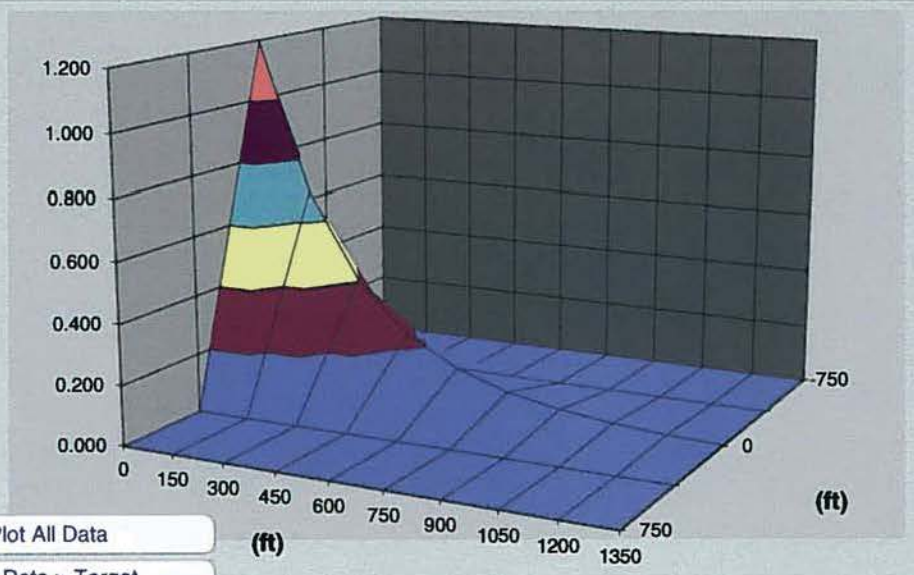
Recalculate This

CAL RUN 7 INPUT, 12.5% M, 1.25 PPM DISSOLVED CHROMIUM CONCENTRATIONS IN LOWER PLUME (mg/L at Z=0)

Transverse Distance (ft) ↓ / Distance from Source (ft) →	0	150	300	450	600	750	900	1050	1200	1350	1500
750	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
375	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000
0	1.192	0.695	0.405	0.236	0.137	0.079	0.045	0.024	0.011	0.004	0.001
-375	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000
-750	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MASS FLUX (mg/day)	1.2E+4	5.6E+3	3.3E+3	1.9E+3	1.1E+3	6.6E+2	3.8E+2	2.0E+2	9.3E+1	3.4E+1	9.7E+0

Model to Display: *No Degradation* | *1st Order Decay* | *Instantaneous*

Time: **7 Years** Target Level: **0.100** mg/L Displayed Model: **1st Order Decay**



Plot All Data

Plot Data > Target

Plume and Source Masses (Order-of-Magnitude Accuracy)

Plume Mass if No Biodegradation	29.1	(Kg)
- Actual Plume Mass	7.1	(Kg)
= Plume Mass Removed by Biodeg	**22.0**	(Kg) (76 %)

Change in Electron Acceptor/Byproduct Masses:

Oxygen	*Nitrate*	*Iron II*	*Sulfate*	*Methane*	
na	na	na	na	na	(Kg)

Contam. Mass in Source (t=0 Years)	625.0	(Kg)
Contam. Mass in Source Now (t=7Years)	595.9	(Kg)
Current Volume of Groundwater in Plume	20.3	(ac-ft)
Flowrate of Water Through Source Zone	3.448	(ac-ft/yr)

Mass HELP

Recalculat

ATTACHMENT 5
BIOSCREEN OUTPUT
SIMULATIONS TO PREDICTING CHROMIUM CONCENTRATIONS AT FARM PARCEL WELLS FROM CAR WASH

BIOSCREEN Natural Attenuation Decision Support System

Air Force Center for Environmental Excellence *Version 1.4*
Simulation of Car Wash Using Cal Run 4a Input for Upper Plume Shield Alloy - Year 3

Upper Cr Plume
Shield Alloy
Run Name

Data Input Instructions:

115
or
0.02

1. Enter value directly....or
2. Calculate by filling in grey cells below. (To restore formulas, hit button below).

Variable* → Data used directly in model.
20 → Value calculated by model. (Don't enter any data).

1. HYDROGEOLOGY

Seepage Velocity*	Vs	521.8	(ft/yr)
or		or	
Hydraulic Conductivity	K	8.9E-02	(cm/sec)
Hydraulic Gradient	i	0.0017	(ft/ft)
Porosity	n	0.3	(-)

2. DISPERSION

Longitudinal Dispersivity*	alpha x	24.5	(ft)
Transverse Dispersivity*	alpha y	2.4	(ft)
Vertical Dispersivity*	alpha z	0.0	(ft)
or		or	
Estimated Plume Length	Lp	1000	(ft)

3. ADSORPTION

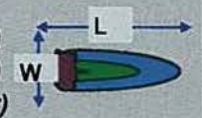
Retardation Factor*	R	1.0	(-)
or		or	
Soil Bulk Density	rho	1.7	(kg/l)
Partition Coefficient	Koc	38	(L/kg)
FractionOrganicCarbon	foc	5.7E-5	(-)

4. GEOCHEMICAL ATTENUATION

1st Order Bulk Att Factor*	lambda	1.8E+0	(per yr)
or		or	
Solute Half-Life	t-half	0.38	(year)
or Instantaneous Reaction Model			
Delta Oxygen*	DO	0	(mg/L)
Delta Nitrate*	NO3	0	(mg/L)
Observed Ferrous Iron*	Fe2+	0	(mg/L)
Delta Sulfate*	SO4	0	(mg/L)
Observed Methane*	CH4	0	(mg/L)

5. GENERAL

Modeled Area Length*	2000	(ft)
Modeled Area Width*	1000	(ft)
Simulation Time*	3	(yr)



6. SOURCE DATA

Source Thickness in Sat.Zone* 8 (ft)

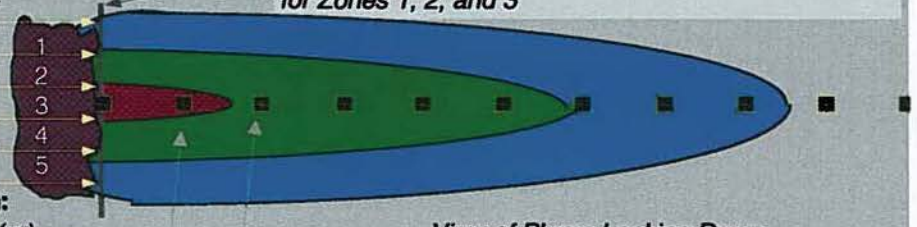
Source Zones:

Width* (ft)	Conc. (mg/L)*
55	0.15
55	0.3
55	0.5
55	0.3
55	0.15

Source Halflife (see Help):

200	200	(yr)
Inst. React.	1st Order	
Soluble Mass	875	(Kg)
In Source NAPL, Soil		

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3



View of Plume Looking Down

Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

7. FIELD DATA FOR COMPARISON

Dist. from Source (ft)	0	200	400	600	800	1000	1200	1400	1600	1800	2000
Concentration (mg/L)											

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN — **View Output**

RUN ARRAY — **View Output**

Help | Recalculate

Paste Example Dataset

Restore Formulas for Vs,

CALRUN 4A Input

UPPER PLUME DISSOLVED CHROMIUM CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

Car Wash

TYPE OF MODEL	Distance from Source (ft) 0	200	400	600	800	1000	1200	1400	1600	1800	2000
No Degradation	0.495	0.419	0.381	0.355	0.333	0.310	0.274	0.210	0.125	0.053	0.015
1st Order Decay	0.495	0.219	0.104	0.051	0.025	0.012	0.006	0.003	0.001	0.000	0.000
Inst. Reaction	0.495	0.419	0.381	0.355	0.333	0.310	0.274	0.210	0.125	0.053	0.015
Field Data from Site											

Calculate

Time: 3 Years

Return to

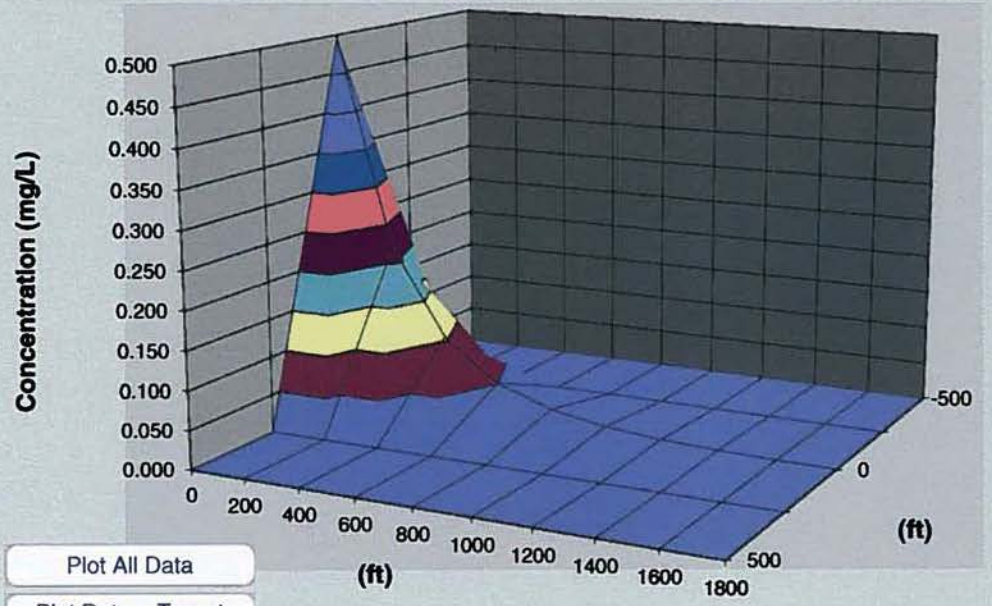
Recalculate This

CAL RUN 4A INPUT CAR WASH DISSOLVED CHROMIUM CONCENTRATIONS IN UPPER PLUME (mg/L at Z=0)

Transverse Distance (ft) ↓ / Distance from Source (ft)	0	200	400	600	800	1000	1200	1400	1600	1800	2000
500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
250	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0	0.495	0.219	0.104	0.051	0.025	0.012	0.006	0.003	0.001	0.000	0.000
-250	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MASS FLUX (mg/day)	7.5E+3	5.3E+3	2.5E+3	1.3E+3	6.3E+2	3.2E+2	1.6E+2	7.9E+1	3.4E+1	1.2E+1	2.9E+0

Model to Display: *No Degradation* | *1st Order Decay* | *Instantaneous*

Time: **3 Years** Target Level: **0.100** mg/L Displayed Model: **1st Order Decay**



Plot All Data

Plot Data > Target

Plume and Source Masses (Order-of-Magnitude Accuracy)

Plume Mass if No Biodegradation	8.1	(Kg)
- Actual Plume Mass	1.9	(Kg)
= Plume Mass Removed by Biodeg	6.2	(Kg) (76 %)

Change in Electron Acceptor/Byproduct Masses:

Oxygen	*Nitrate*	*Iron II*	*Sulfate*	*Methane*	
na	na	na	na	na	(Kg)

Contam. Mass in Source (t=0 Years)	875.0	(Kg)
Contam. Mass in Source Now (t=3Years)	866.9	(Kg)
Current Volume of Groundwater in Plume	19.3	(ac-ft)
Flowrate of Water Through Source Zone	7.906	(ac-ft/yr)

Mass HELP

Recalculat

BIOSCREEN Natural Attenuation Decision Support System

Air Force Center for Environmental Excellence — *Version 1.4*

Cal Run 4a r1 Input for Car Wash Contribution to Upper Plume Shield Alloy - Year 3

Upper Cr Plume / Shield Alloy — Run Name

Data Input Instructions:

115 or 0.02 — 1. Enter value directly....or 2. Calculate by filling in grey cells below. (To restore formulas, hit button below).

Variable* — Data used directly in model.

20 — Value calculated by model. (Don't enter any data).

1. HYDROGEOLOGY

Seepage Velocity*	Vs	782.7	(ft/yr)
or		or	
Hydraulic Conductivity	K	8.9E-02	(cm/sec)
Hydraulic Gradient	i	0.0017	(ft/ft)
Porosity	n	0.2	(-)

2. DISPERSION

Longitudinal Dispersivity*	alpha x	24.5	(ft)
Transverse Dispersivity*	alpha y	2.4	(ft)
Vertical Dispersivity*	alpha z	0.0	(ft)
or		or	
Estimated Plume Length	Lp	1000	(ft)

3. ADSORPTION

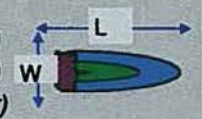
Retardation Factor*	R	1.0	(-)
or		or	
Soil Bulk Density	rho	1.7	(kg/l)
Partition Coefficient	Koc	38	(L/kg)
FractionOrganicCarbon	foc	5.7E-5	(-)

4. GEOCHEMICAL ATTENUATION

1st Order Bulk Att Factor*	lambda	1.8E+0	(per yr)
or		or	
Solute Half-Life	t-half	0.38	(year)
or Instantaneous Reaction Model			
Delta Oxygen*	DO	0	(mg/L)
Delta Nitrate*	NO3	0	(mg/L)
Observed Ferrous Iron*	Fe2+	0	(mg/L)
Delta Sulfate*	SO4	0	(mg/L)
Observed Methane*	CH4	0	(mg/L)

5. GENERAL

Modeled Area Length*	2000	(ft)
Modeled Area Width*	1000	(ft)
Simulation Time*	3	(yr)



6. SOURCE DATA

Source Thickness in Sat.Zone* 7 (ft)

Source Zones:

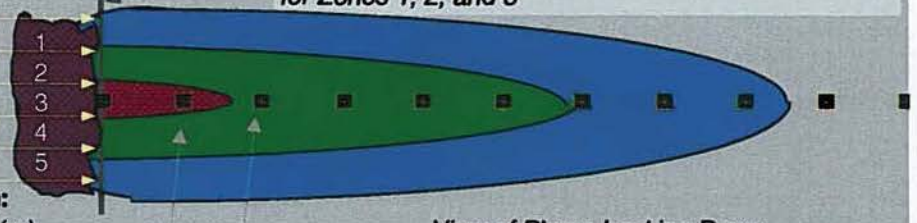
Width* (ft)	Conc. (mg/L)*
55	0.15
55	0.3
55	0.5
55	0.3
55	0.15

Source Halflife (see Help):

Inst. React.	1st Order
300	300 (yr)

Soluble Mass 875 (Kg) In Source NAPL, Soil

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3



View of Plume Looking Down

Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

7. FIELD DATA FOR COMPARISON

Dist. from Source (ft)	Concentration (mg/L)
0	
200	
400	
600	
800	
1000	
1200	
1400	
1600	
1800	
2000	

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN — View Output

RUN ARRAY — View Output

Help — Recalculate

Paste Example Dataset

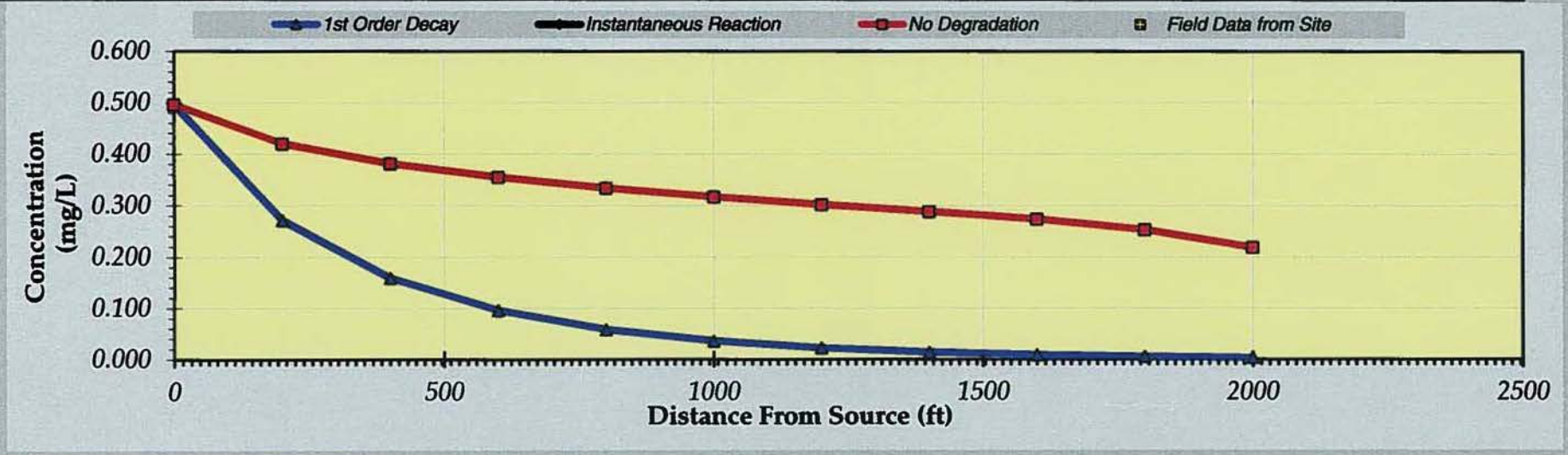
Restore Formulas for Vs,

CAL RUN A4 r1 Input

UPPER PLUME DISSOLVED CHROMIUM CONCENTRATION ALONG CENTERLINE (mg/L at Z=0)

Car Wash

TYPE OF MODEL	Distance from Source (ft) 0	200	400	600	800	1000	1200	1400	1600	1800	2000
No Degradation	0.496	0.420	0.381	0.355	0.334	0.316	0.302	0.288	0.274	0.253	0.219
1st Order Decay	0.496	0.271	0.159	0.096	0.058	0.036	0.022	0.014	0.008	0.005	0.003
Inst. Reaction	0.496	0.420	0.381	0.355	0.334	0.316	0.302	0.288	0.274	0.253	0.219
Field Data from Site											



Calculate

Time: 3 Years

Return to

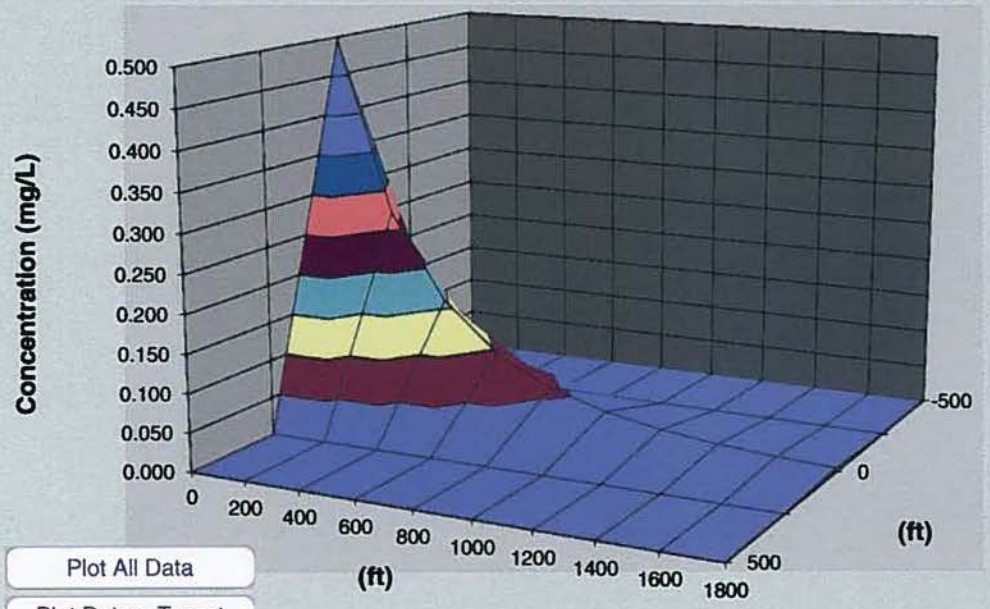
Recalculate This

CAL RUN 4A R1 INPUT CAR WASH - CHROMIUM CONCENTRATIONS IN UPPER PLUME (mg/L at Z=0)

Transverse Distance (ft) ↓ / Distance from Source (ft) →	0	200	400	600	800	1000	1200	1400	1600	1800	2000
500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
250	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000
0	0.496	0.271	0.159	0.096	0.058	0.036	0.022	0.014	0.008	0.005	0.003
-250	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000
-500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MASS FLUX (mg/day)	6.5E+3	5.8E+3	3.4E+3	2.1E+3	1.3E+3	8.0E+2	5.1E+2	3.2E+2	2.1E+2	1.3E+2	8.1E+1

Model to Display: No Degradation | 1st Order Decay | Instantaneous

Time: 3 Years Target Level: 0.100 mg/L Displayed Model: 1st Order Decay



Plot All Data

Plot Data > Target

Plume and Source Masses (Order-of-Magnitude Accuracy)

Plume Mass if No Biodegradation	7.1	(Kg)
- Actual Plume Mass	1.8	(Kg)
= Plume Mass Removed by Biodeg	5.3	(Kg) (74 %)

Change in Electron Acceptor/Byproduct Masses:

Oxygen	Nitrate	Iron II	Sulfate	Methane	
na	na	na	na	na	(Kg)

Contam. Mass in Source (t=0 Years)	875.0	(Kg)
Contam. Mass in Source Now (t=3Years)	867.9	(Kg)
Current Volume of Groundwater in Plume	16.1	(ac-ft)
Flowrate of Water Through Source Zone	6.918	(ac-ft/yr)

Mass HELP

Recalculat

BIOSCREEN Natural Attenuation Decision Support System

Air Force Center for Environmental Excellence — *Version 1.4*

Cal Run 5a r1 Input for Car Wash Contributions to Upper Plume Shield Alloy - Year 3

Upper Cr Plume
Shield Alloy
Run Name

Data Input Instructions:

115 or 0.02

1. Enter value directly....or
2. Calculate by filling in grey cells below. (To restore formulas, hit button below).

Variable* — Data used directly in model.

20 — Value calculated by model. (Don't enter any data).

1. HYDROGEOLOGY

Seepage Velocity*	Vs	452.3	(ft/yr)
or		or	
Hydraulic Conductivity	K	9.0E-02	(cm/sec)
Hydraulic Gradient	i	0.0017	(ft/ft)
Porosity	n	0.35	(-)

2. DISPERSION

Longitudinal Dispersivity*	alpha x	28.9	(ft)
Transverse Dispersivity*	alpha y	2.9	(ft)
Vertical Dispersivity*	alpha z	0.0	(ft)
or		or	
Estimated Plume Length	Lp	1500	(ft)

3. ADSORPTION

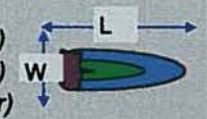
Retardation Factor*	R	1.0	(-)
or		or	
Soil Bulk Density	rho	1.7	(kg/l)
Partition Coefficient	Koc	38	(L/kg)
FractionOrganicCarbon	foc	5.7E-5	(-)

4. GEOCHEMICAL ATTENUATION

1st Order Bulk Att Factor*	lambda	1.7E+0	(per yr)
or		or	
Solute Half-Life	t-half	0.40	(year)
or Instantaneous Reaction Model			
Delta Oxygen*	DO	0	(mg/L)
Delta Nitrate*	NO3	0	(mg/L)
Observed Ferrous Iron*	Fe2+	0	(mg/L)
Delta Sulfate*	SO4	0	(mg/L)
Observed Methane*	CH4	0	(mg/L)

5. GENERAL

Modeled Area Length*	2000	(ft)
Modeled Area Width*	1000	(ft)
Simulation Time*	3	(yr)



6. SOURCE DATA

Source Thickness in Sat.Zone* 9 (ft)

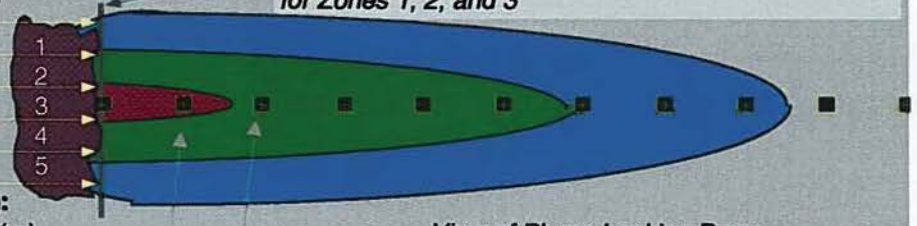
Source Zones:

Width* (ft)	Conc. (mg/L)*	
55	0.15	1
55	0.3	2
55	0.5	3
55	0.3	4
55	0.15	5

Source Halflife (see Help):

200	200	(yr)
Inst. React.	1st Order	
Soluble Mass	950	(Kg)
In Source NAPL, Soil		

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3



View of Plume Looking Down

Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

7. FIELD DATA FOR COMPARISON

Dist. from Source (ft)	0	200	400	600	800	1000	1200	1400	1600	1800	2000
Concentration (mg/L)											

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN — **View Output**

RUN ARRAY — **View Output**

Help | Recalculate

Paste Example Dataset

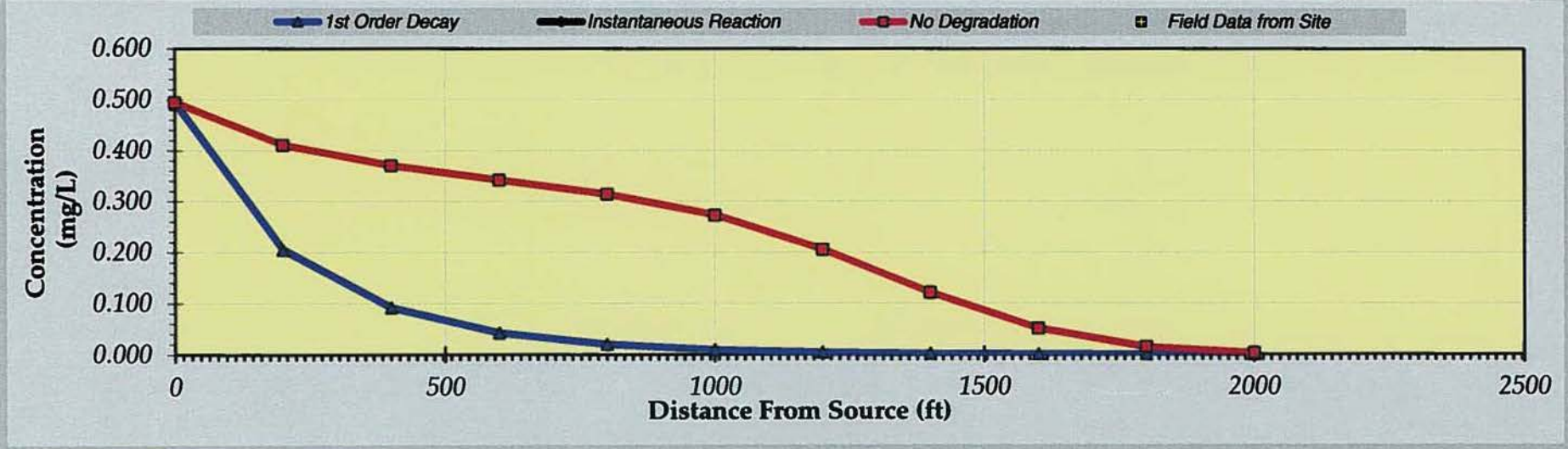
Restore Formulas for Vs,

CAL RUN 5AR1 Input

CAR WASH CONTRIBUTIONS TO CHROMIUM CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

Car Wash Simulation

TYPE OF MODEL	Distance from Source (ft) 0	200	400	600	800	1000	1200	1400	1600	1800	2000
No Degradation	0.495	0.411	0.370	0.342	0.314	0.273	0.205	0.121	0.051	0.014	0.003
1st Order Decay	0.495	0.205	0.092	0.042	0.020	0.009	0.004	0.002	0.001	0.000	0.000
Inst. Reaction	0.495	0.411	0.370	0.342	0.314	0.273	0.205	0.121	0.051	0.014	0.003
Field Data from Site											



Calculate

Time: 3 Years

Return to

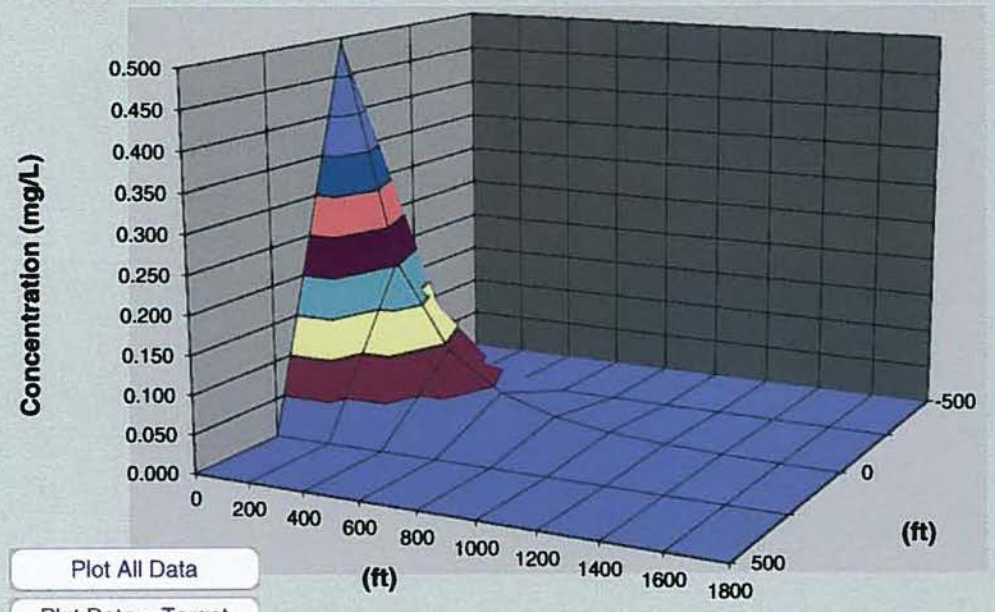
Recalculate This

BIOCHLOR V2.5A R1 INPUT CAR WASH CONTRIBUTIONS OF DISSOLVED CHROMIUM CONCENTRATIONS IN UPPER PLUME (mg/L at Z=0)

Transverse Distance (ft) ↓ / Distance from Source (ft) →	0	200	400	600	800	1000	1200	1400	1600	1800	2000
500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
250	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000
0	0.495	0.205	0.092	0.042	0.020	0.009	0.004	0.002	0.001	0.000	0.000
-250	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000
-500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MASS FLUX (mg/day)	8.5E+3	5.7E+3	2.6E+3	1.2E+3	5.8E+2	2.8E+2	1.3E+2	5.3E+1	1.8E+1	4.5E+0	7.6E-1

Model to Display: No Degradation | 1st Order Decay | Instantaneous

Time: 3 Years Target Level: 0.100 mg/L Displayed Model: 1st Order Decay



Plot All Data

Plot Data > Target

Plume and Source Masses (Order-of-Magnitude Accuracy)

Plume Mass if No Biodegradation	9.3	(Kg)
- Actual Plume Mass	2.4	(Kg)
= Plume Mass Removed by Biodeg	6.9	(Kg) (75 %)

Change in Electron Acceptor/Byproduct Masses:

Oxygen	Nitrate	Iron II	Sulfate	Methane	
na	na	na	na	na	(Kg)

Contam. Mass in Source (t=0 Years)	950.0	(Kg)
Contam. Mass in Source Now (t=3Years)	940.7	(Kg)
Current Volume of Groundwater in Plume	21.7	(ac-ft)
Flowrate of Water Through Source Zone	8.994	(ac-ft/yr)

Mass HELP

Recalculat

BIOSCREEN Natural Attenuation Decision Support System

Air Force Center for Environmental Excellence — *Version 1.4*

Calibration run 5 Input for Car Wash Chromium Concentration Contribution to Lower Aquifer - Year 9

Lower Cr Plume
Shield Alloy
Run Name

Data Input Instructions:

115 or 0.02

1. Enter value directly....or
2. Calculate by filling in grey cells below. (To restore formulas, hit button below).

Variable* — Data used directly in model.

20 — Value calculated by model. (Don't enter any data).

1. HYDROGEOLOGY

Seepage Velocity*	Vs	298.0	(ft/yr)
or		↑ or	
Hydraulic Conductivity	K	3.6E-02	(cm/sec)
Hydraulic Gradient	i	0.0016	(ft/ft)
Porosity	n	0.2	(-)

2. DISPERSION

Longitudinal Dispersivity*	alpha x	24.5	(ft)
Transverse Dispersivity*	alpha y	2.4	(ft)
Vertical Dispersivity*	alpha z	0.0	(ft)
or		↑ or	
Estimated Plume Length	Lp	1000	(ft)

3. ADSORPTION

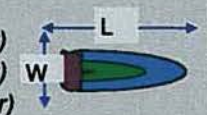
Retardation Factor*	R	1.0	(-)
or		↑ or	
Soil Bulk Density	rho	1.7	(kg/l)
Partition Coefficient	Koc	1000	(L/kg)
FractionOrganicCarbon	foc	5.7E-6	(-)

4. BIODEGRADATION

1st Order Decay Coeff*	lambda	8.3E-1	(per yr)
or		↑ or	
Solute Half-Life	t-half	0.83	(year)
or Instantaneous Reaction Model			
Delta Oxygen*	DO	0	(mg/L)
Delta Nitrate*	NO3	0	(mg/L)
Observed Ferrous Iron*	Fe2+	0	(mg/L)
Delta Sulfate*	SO4	0	(mg/L)
Observed Methane*	CH4	0	(mg/L)

5. GENERAL

Modeled Area Length*	2000	(ft)
Modeled Area Width*	1000	(ft)
Simulation Time*	9	(yr)



6. SOURCE DATA

Source Thickness in Sat.Zone* 7 (ft)

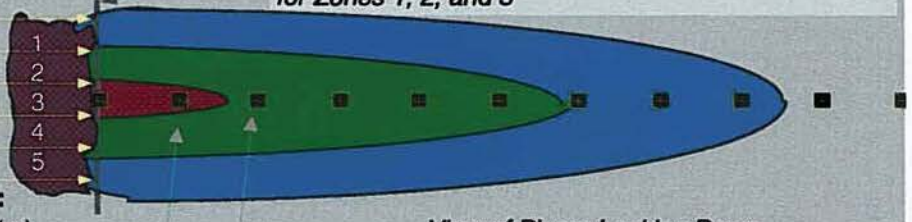
Source Zones:

Width* (ft)	Conc. (mg/L)*
83	0.06
333	0.55
383	2.7
333	0.55
83	0.06

Source Halflife (see Help):

100	100	(yr)
Inst. React. ↑	↑ 1st Order	
Soluble Mass	2500	(Kg)
In Source Soil porewater		

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3



View of Plume Looking Down

Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

7. FIELD DATA FOR COMPARISON

Dist. from Source (ft)	Concentration (mg/L)
0	
200	
400	
600	
800	
1000	
1200	
1400	
1600	
1800	
2000	

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN — **View Output**

RUN ARRAY — **View Output**

Help — Recalculate

Paste Example Dataset

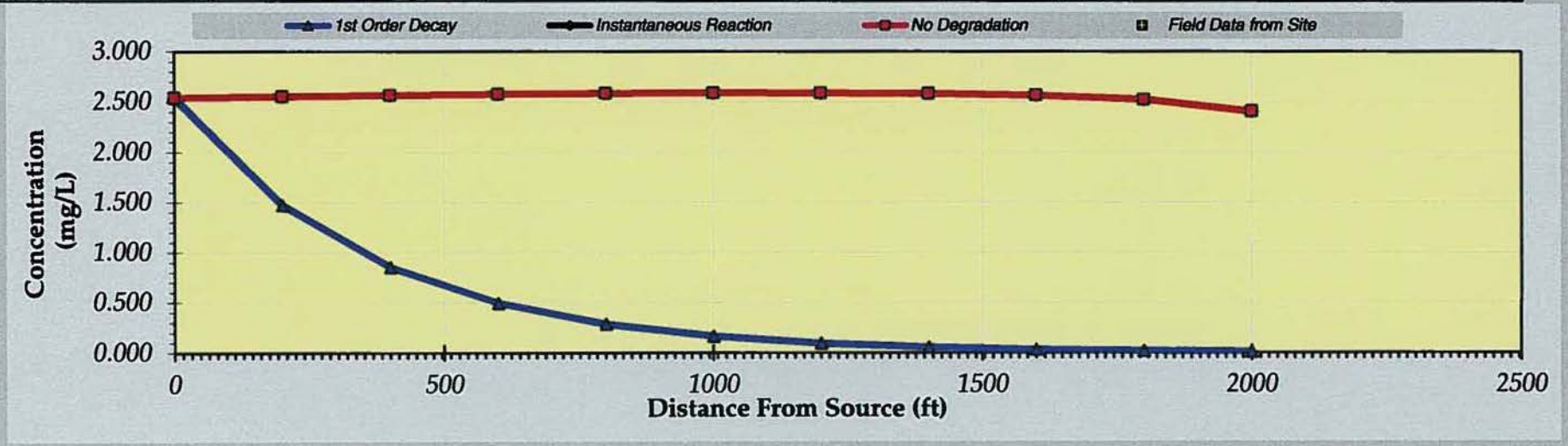
Restore Formulas for Vs,

CAL RUN 5 Input

CAR WASH CHROMIUM CONCENTRATIONS ALONG CENTERLINE OF LOWER PLUME(mg/L at Z=0)

Car Wash Contribution

TYPE OF MODEL	Distance from Source (ft) 0	200	400	600	800	1000	1200	1400	1600	1800	2000
No Degradation	2.543	2.555	2.567	2.578	2.586	2.590	2.589	2.583	2.567	2.524	2.406
1st Order Decay	2.543	1.473	0.854	0.494	0.286	0.165	0.095	0.055	0.032	0.018	0.010
Inst. Reaction	2.543	2.555	2.567	2.578	2.586	2.590	2.589	2.583	2.567	2.524	2.406
Field Data from Site											



Calculate

Time:
9 Years

Return to

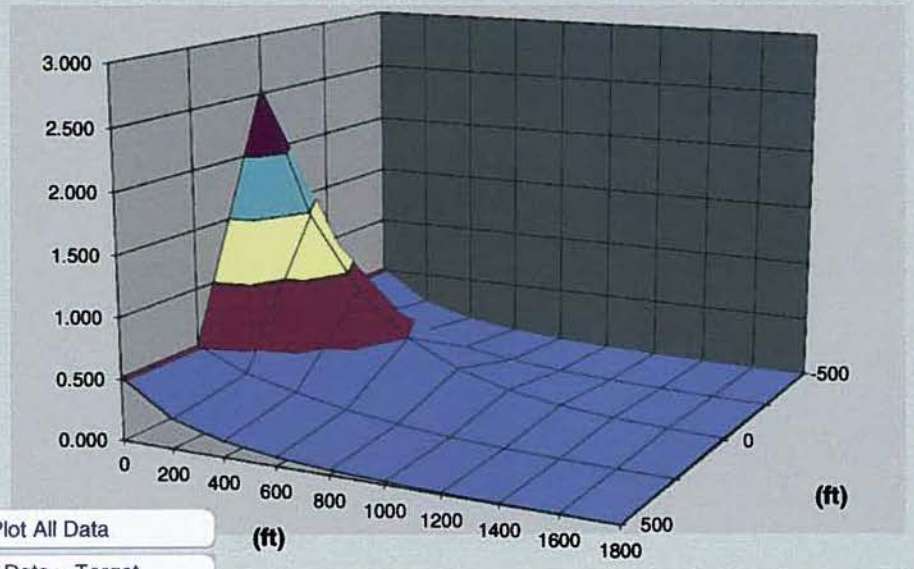
Recalculate This

AL RUN 5 INPUT CAR WASH CONTRIBUTIONS OF DISSOLVED CHROMIUM CONCENTRATIONS IN LOWER PLUME (mg/L at Z=0)

Transverse Distance (ft) ↓ / Distance from Source (ft)	0	200	400	600	800	1000	1200	1400	1600	1800	2000
500	0.518	0.242	0.129	0.071	0.040	0.023	0.013	0.007	0.004	0.002	0.001
250	0.518	0.336	0.237	0.156	0.098	0.060	0.037	0.022	0.013	0.008	0.005
0	2.543	1.473	0.854	0.494	0.286	0.165	0.095	0.055	0.032	0.018	0.010
-250	0.518	0.336	0.237	0.156	0.098	0.060	0.037	0.022	0.013	0.008	0.005
-500	0.518	0.242	0.129	0.071	0.040	0.023	0.013	0.007	0.004	0.002	0.001
MASS FLUX (mg/day)	4.6E+4	2.1E+4	1.3E+4	7.7E+3	4.6E+3	2.7E+3	1.6E+3	9.2E+2	5.3E+2	3.1E+2	1.8E+2

Model to Display: No Degradation | 1st Order Decay | Instantaneous

Time: 9 Years Target Level: 0.100 mg/L Displayed Model: 1st Order Decay



Plot All Data

Plot Data > Target

Plume and Source Masses (Order-of-Magnitude Accuracy)

Plume Mass if No Biodegradation	145.5	(Kg)
- Actual Plume Mass	22.8	(Kg)
= Plume Mass Removed by Biodeg	122.6	(Kg) (84 %)

Change in Electron Acceptor/Byproduct Masses:

Oxygen	Nitrate	Iron II	Sulfate	Methane	
na	na	na	na	na	(Kg)

Contam. Mass in Source (t=0 Years)	2500.0	(Kg)
Contam. Mass in Source Now (t=9Years)	2354.5	(Kg)
Current Volume of Groundwater in Plume	75.5	(ac-ft)
Flowrate of Water Through Source Zone	11.636	(ac-ft/yr)

Mass HELP

Recalculat

BIOSCREEN Natural Attenuation Decision Support System

Air Force Center for Environmental Excellence — *Version 1.4*

Cal Run 6 Input for Car Wash Chromium Concentration Contribution to Lower Plume - year 8

Lower Cr Plume
Shield Alloy
Run Name

Data Input Instructions:

115 or 0.02

1. Enter value directly....or
2. Calculate by filling in grey cells below. (To restore formulas, hit button below).

Variable* — Data used directly in model.
20 — Value calculated by model. (Don't enter any data).

1. HYDROGEOLOGY

Seepage Velocity*	Vs	298.0	(ft/yr)
or		↑ or	
Hydraulic Conductivity	K	3.6E-02	(cm/sec)
Hydraulic Gradient	i	0.0016	(ft/ft)
Porosity	n	0.2	(-)

2. DISPERSION

Longitudinal Dispersivity*	alpha x	24.5	(ft)
Transverse Dispersivity*	alpha y	2.4	(ft)
Vertical Dispersivity*	alpha z	0.0	(ft)
or		↑ or	
Estimated Plume Length	Lp	1000	(ft)

3. ADSORPTION

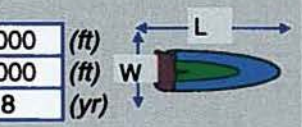
Retardation Factor*	R	1.0	(-)
or		↑ or	
Soil Bulk Density	rho	1.7	(kg/l)
Partition Coefficient	Koc	1000	(L/kg)
FractionOrganicCarbon	foc	5.7E-6	(-)

4. BIODEGRADATION

1st Order Decay Coeff*	lambda	1.0E+0	(per yr)
or		↑ or	
Solute Half-Life	t-half	0.69	(year)
or Instantaneous Reaction Model			
Delta Oxygen*	DO	0	(mg/L)
Delta Nitrate*	NO3	0	(mg/L)
Observed Ferrous Iron*	Fe2+	0	(mg/L)
Delta Sulfate*	SO4	0	(mg/L)
Observed Methane*	CH4	0	(mg/L)

5. GENERAL

Modeled Area Length*	2000	(ft)
Modeled Area Width*	1000	(ft)
Simulation Time*	8	(yr)



6. SOURCE DATA

Source Thickness in Sat.Zone* 7 (ft)

Source Zones:

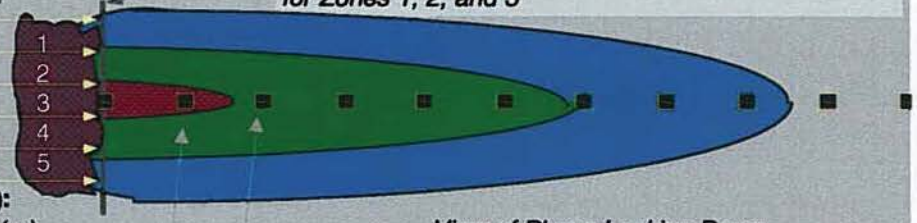
Width* (ft)	Conc. (mg/L)*	
83	0.06	1
333	0.55	2
383	2.7	3
333	0.55	4
83	0.06	5

Source Halflife (see Help):

90	90	(yr)
Inst. React. ↑	↑ 1st Order	
Soluble Mass	2250	(Kg)

In Source Soil porewater

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3



View of Plume Looking Down

Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

7. FIELD DATA FOR COMPARISON

Dist. from Source (ft)	0	200	400	600	800	1000	1200	1400	1600	1800	2000
Concentration (mg/L)											

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN — View Output

RUN ARRAY — View Output

Help — Recalculate

Paste Example Dataset

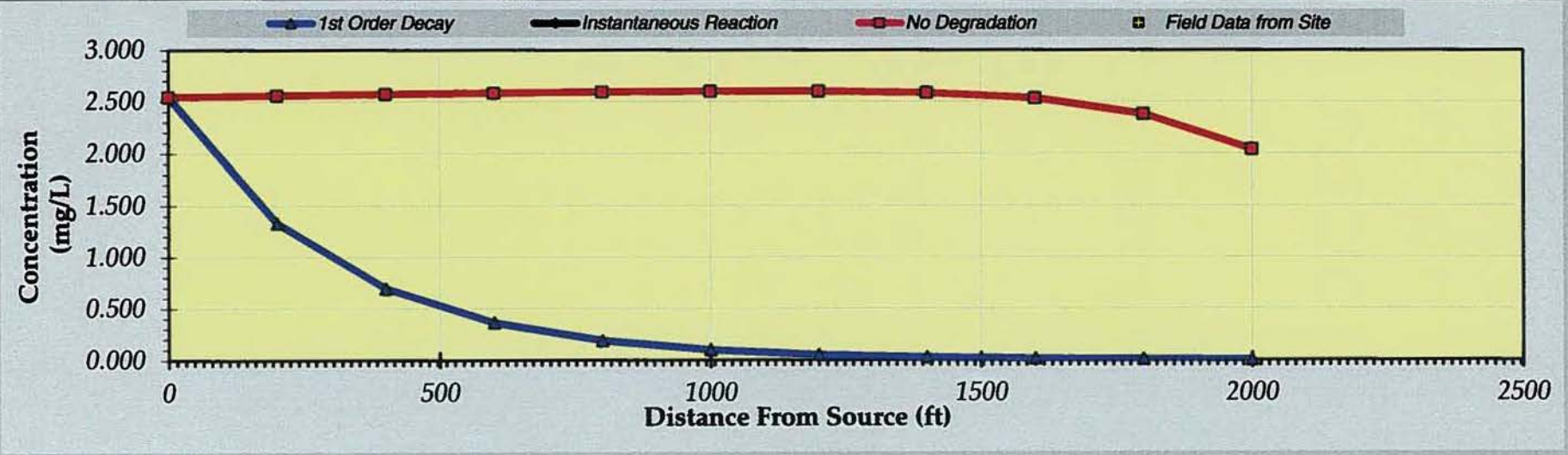
Restore Formulas for Vs,

CAL RUN 6 Input

/ASH CONTRIBUTION OF DISSOLVED CHROMIUM CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

Car Wash Contribution

TYPE OF MODEL	Distance from Source (ft) 0	200	400	600	800	1000	1200	1400	1600	1800	2000
No Degradation	2.545	2.558	2.571	2.584	2.594	2.599	2.598	2.584	2.532	2.378	2.039
1st Order Decay	2.545	1.330	0.695	0.363	0.189	0.099	0.051	0.027	0.014	0.007	0.004
Inst. Reaction	2.545	2.558	2.571	2.584	2.594	2.599	2.598	2.584	2.532	2.378	2.039
Field Data from Site											



Calculate

Time: 8 Years

Return to

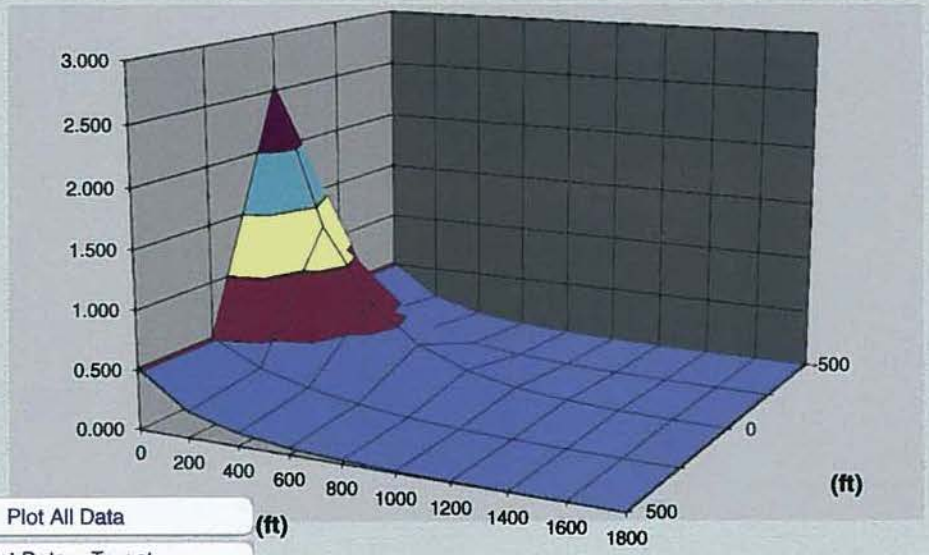
Recalculate This

CAL RUN 6 INPUT, CAR WASH CONTRIBUTION OF DISSOLVED CHROMIUM CONCENTRATIONS IN LOWER PLUME (mg/L at Z=0)

Transverse Distance (ft) ↓	Distance from Source (ft) 0	200	400	600	800	1000	1200	1400	1600	1800	2000
500	0.518	0.219	0.105	0.052	0.026	0.014	0.007	0.004	0.002	0.001	0.000
250	0.518	0.303	0.193	0.114	0.065	0.036	0.020	0.011	0.006	0.003	0.002
0	2.545	1.330	0.695	0.363	0.189	0.099	0.051	0.027	0.014	0.007	0.004
-250	0.518	0.303	0.193	0.114	0.065	0.036	0.020	0.011	0.006	0.003	0.002
-500	0.518	0.219	0.105	0.052	0.026	0.014	0.007	0.004	0.002	0.001	0.000
MASS FLUX (mg/day)	4.6E+4	1.9E+4	1.0E+4	5.6E+3	3.0E+3	1.6E+3	8.5E+2	4.5E+2	2.3E+2	1.2E+2	6.3E+1

Model to Display: No Degradation | 1st Order Decay | Instantaneous

Time: 8 Years Target Level: 0.100 mg/L Displayed Model: 1st Order Decay



Plot All Data

Plot Data > Target

Plume and Source Masses (Order-of-Magnitude Accuracy)

Plume Mass if No Biodegradation	129.3	(Kg)
- Actual Plume Mass	17.6	(Kg)
= Plume Mass Removed by Biodeg	111.8	(Kg) (86 %)

Change in Electron Acceptor/Byproduct Masses:

Oxygen	Nitrate	Iron II	Sulfate	Methane	
na	na	na	na	na	(Kg)

Contam. Mass in Source (t=0 Years)	2250.0	(Kg)
Contam. Mass in Source Now (t=8Years)	2120.7	(Kg)
Current Volume of Groundwater in Plume	67.5	(ac-ft)
Flowrate of Water Through Source Zone	11.636	(ac-ft/yr)

Mass HELP Recalculat

BIOSCREEN Natural Attenuation Decision Support System

Air Force Center for Environmental Excellence — *Version 1.4*

Cal Run 7 Input for Car Wash Chromium Contribution to Lower Plume -Year 11

Lower Cr Plume
Shield Alloy
Run Name

Data Input Instructions:

115 or 0.02

1. Enter value directly....or
2. Calculate by filling in grey cells below. (To restore formulas, hit button below).

Variable* — Data used directly in model.

20 — Value calculated by model. (Don't enter any data).

1. HYDROGEOLOGY

Seepage Velocity*	Vs	158.9	(ft/yr)
or		or	
Hydraulic Conductivity	K	2.4E-02	(cm/sec)
Hydraulic Gradient	i	0.0016	(ft/ft)
Porosity	n	0.25	(-)

2. DISPERSION

Longitudinal Dispersivity*	alpha x	24.5	(ft)
Transverse Dispersivity*	alpha y	2.4	(ft)
Vertical Dispersivity*	alpha z	0.0	(ft)
or		or	
Estimated Plume Length	Lp	1000	(ft)

3. ADSORPTION

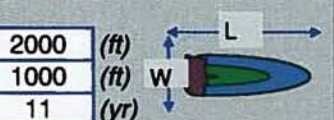
Retardation Factor*	R	1.0	(-)
or		or	
Soil Bulk Density	rho	1.7	(kg/l)
Partition Coefficient	Koc	1000	(L/kg)
FractionOrganicCarbon	foc	5.7E-6	(-)

4. BIODEGRADATION

1st Order Decay Coeff*	lambda	6.3E-1	(per yr)
or		or	
Solute Half-Life	t-half	1.10	(year)
or Instantaneous Reaction Model			
Delta Oxygen*	DO	0	(mg/L)
Delta Nitrate*	NO3	0	(mg/L)
Observed Ferrous Iron*	Fe2+	0	(mg/L)
Delta Sulfate*	SO4	0	(mg/L)
Observed Methane*	CH4	0	(mg/L)

5. GENERAL

Modeled Area Length*	2000	(ft)
Modeled Area Width*	1000	(ft)
Simulation Time*	11	(yr)



6. SOURCE DATA

Source Thickness in Sat.Zone* 7 (ft)

Source Zones:

Zone	Width* (ft)	Conc. (mg/L)*
1	83	0.06
2	333	0.55
3	383	2.7
4	333	0.55
5	83	0.06

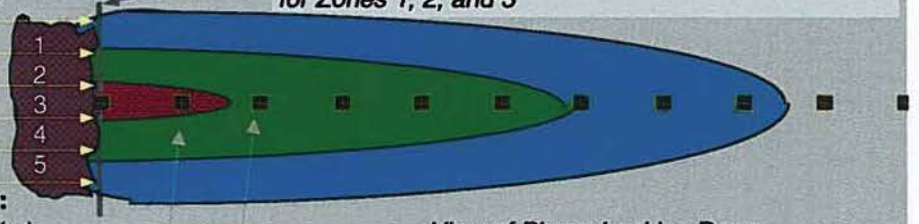
Source Halflife (see Help): 80 | 80 (yr)

Inst. React. | 1st Order

Soluble Mass 1250 (Kg)

In Source Soil porewater

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3



View of Plume Looking Down

Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

7. FIELD DATA FOR COMPARISON

Dist. from Source (ft)	Concentration (mg/L)
0	
200	
400	
600	
800	
1000	
1200	
1400	
1600	
1800	
2000	

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN — **View Output**

RUN ARRAY — **View Output**

Help — Recalculate

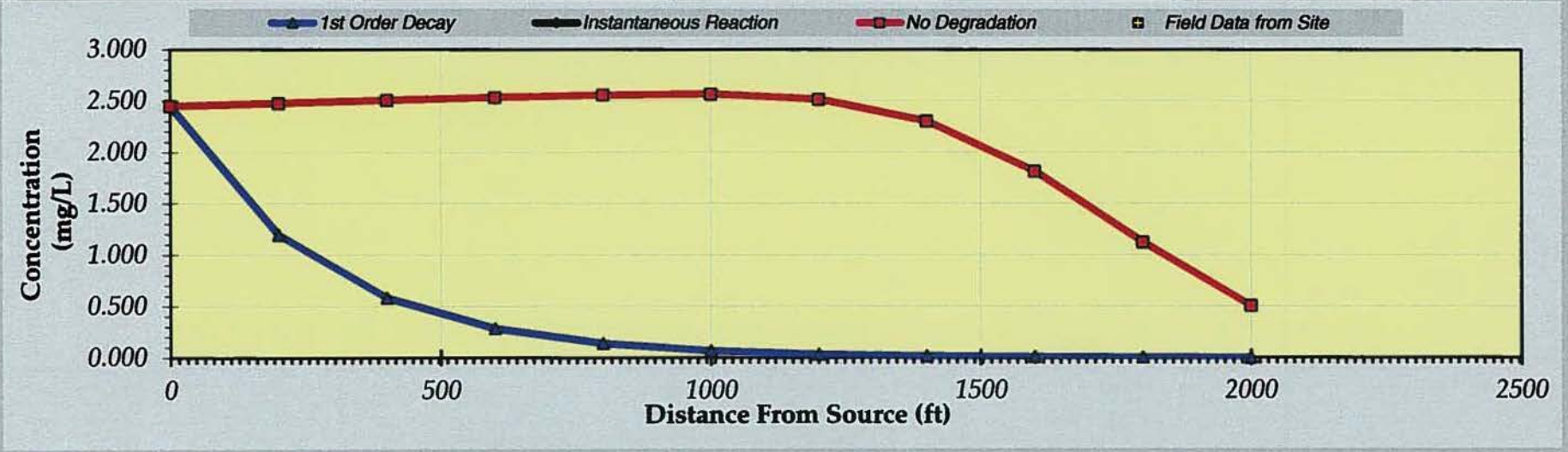
Paste Example Dataset

Restore Formulas for Vs,

CAL RUN 7 INPUT — CONTRIBUTION OF DISSOLVED CHROMIUM CONCENTRATION ALONG LOWER PLUME CENTERLINE (mg/L at Z=0

CAR WASH

TYPE OF MODEL	Distance from Source (ft) 0	200	400	600	800	1000	1200	1400	1600	1800	2000
No Degradation	2.449	2.476	2.504	2.531	2.555	2.563	2.513	2.299	1.812	1.122	0.503
1st Order Decay	2.449	1.196	0.584	0.285	0.139	0.068	0.033	0.016	0.007	0.003	0.001
Inst. Reaction	2.449	2.476	2.504	2.531	2.555	2.563	2.513	2.299	1.812	1.122	0.503
Field Data from Site											



Calculate

Time: 11 Years

Return to

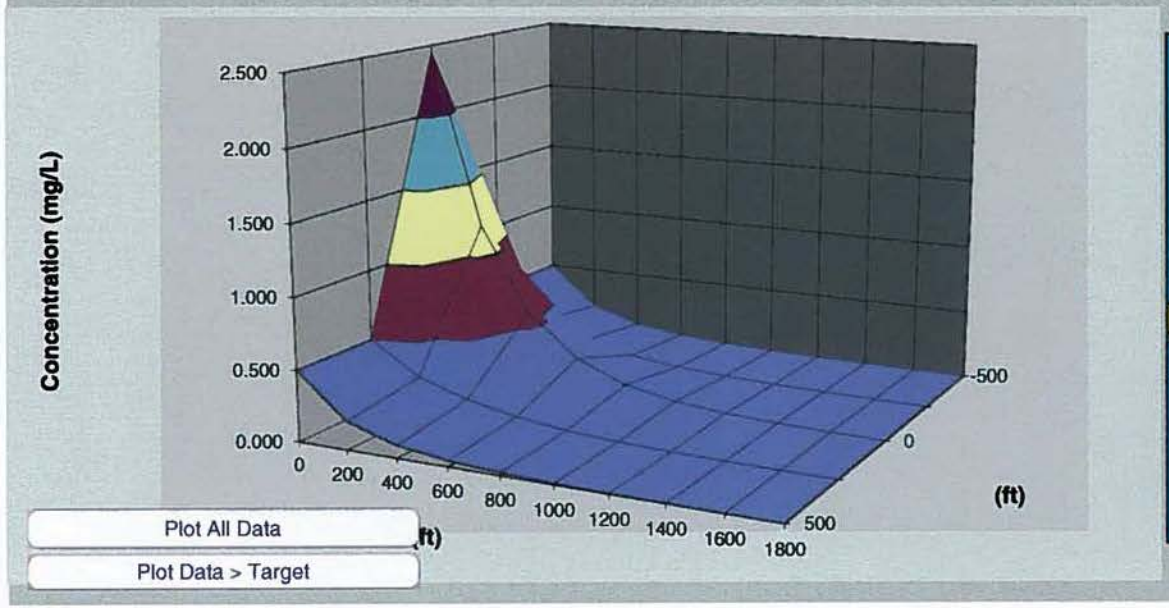
Recalculate This

CAL RUN 7 INPUT- CAR WASH CONTRIBUTION OF DISSOLVED CHROMIUM CONCENTRATIONS IN LOWER PLUME (mg/L at Z=0)

Transverse Distance (ft) ↓ / Distance from Source (ft)	0	200	400	600	800	1000	1200	1400	1600	1800	2000
500	0.499	0.197	0.088	0.041	0.019	0.009	0.004	0.002	0.001	0.000	0.000
250	0.499	0.273	0.162	0.090	0.048	0.025	0.013	0.006	0.003	0.001	0.000
0	2.449	1.196	0.584	0.285	0.139	0.068	0.033	0.016	0.007	0.003	0.001
-250	0.499	0.273	0.162	0.090	0.048	0.025	0.013	0.006	0.003	0.001	0.000
-500	0.499	0.197	0.088	0.041	0.019	0.009	0.004	0.002	0.001	0.000	0.000
MASS FLUX (mg/day)	3.0E+4	1.2E+4	5.8E+3	2.9E+3	1.5E+3	7.3E+2	3.6E+2	1.8E+2	8.2E+1	3.5E+1	1.2E+1

Model to Display: *No Degradation* | *1st Order Decay* | *Instantaneous*

Time: 11 Years Target Level: 0.100 mg/L Displayed Model: 1st Order Decay



Plot All Data

Plot Data > Target

Plume and Source Masses (Order-of-Magnitude Accuracy)

Plume Mass if No Biodegradation	116.3	(Kg)
- Actual Plume Mass	17.4	(Kg)
= Plume Mass Removed by Biodeg	98.9	(Kg) (85 %)

Change in Electron Acceptor/Byproduct Masses:

Oxygen	Nitrate	Iron II	Sulfate	Methane	
na	na	na	na	na	(Kg)

Contam. Mass in Source (t=0 Years)	1250.0	(Kg)
Contam. Mass in Source Now (t=11Years)	1133.7	(Kg)
Current Volume of Groundwater in Plume	74.3	(ac-ft)
Flowrate of Water Through Source Zone	7.757	(ac-ft/yr)

Mass HELP

Recalculat

ATTACHMENT 6
MODEL CALIBRATION STATISTICS

Attachment 6
Statistical Analysis of Calibrated BIOSCREEN Model
Upper Plume
Sorption and Chemical Reduction Simulated as
Combined Bulk Attenuation Process
Shieldalloy Site
Newfields, New Jersey

Zone	BIOSCREEN Calibration Run No.	Well ID	Observed Cr Concentration (mg/l)	Predicted Cr Concentration (mg/l)
Upper Zone	4a r1	U7-B	8.3	8.1
		U8-B	4.7	4.6
		U7-A	3.6	3
		U8-C	2.1	3.1
		U8-E	1.5	1.5
		U7-D	0.3	0.35

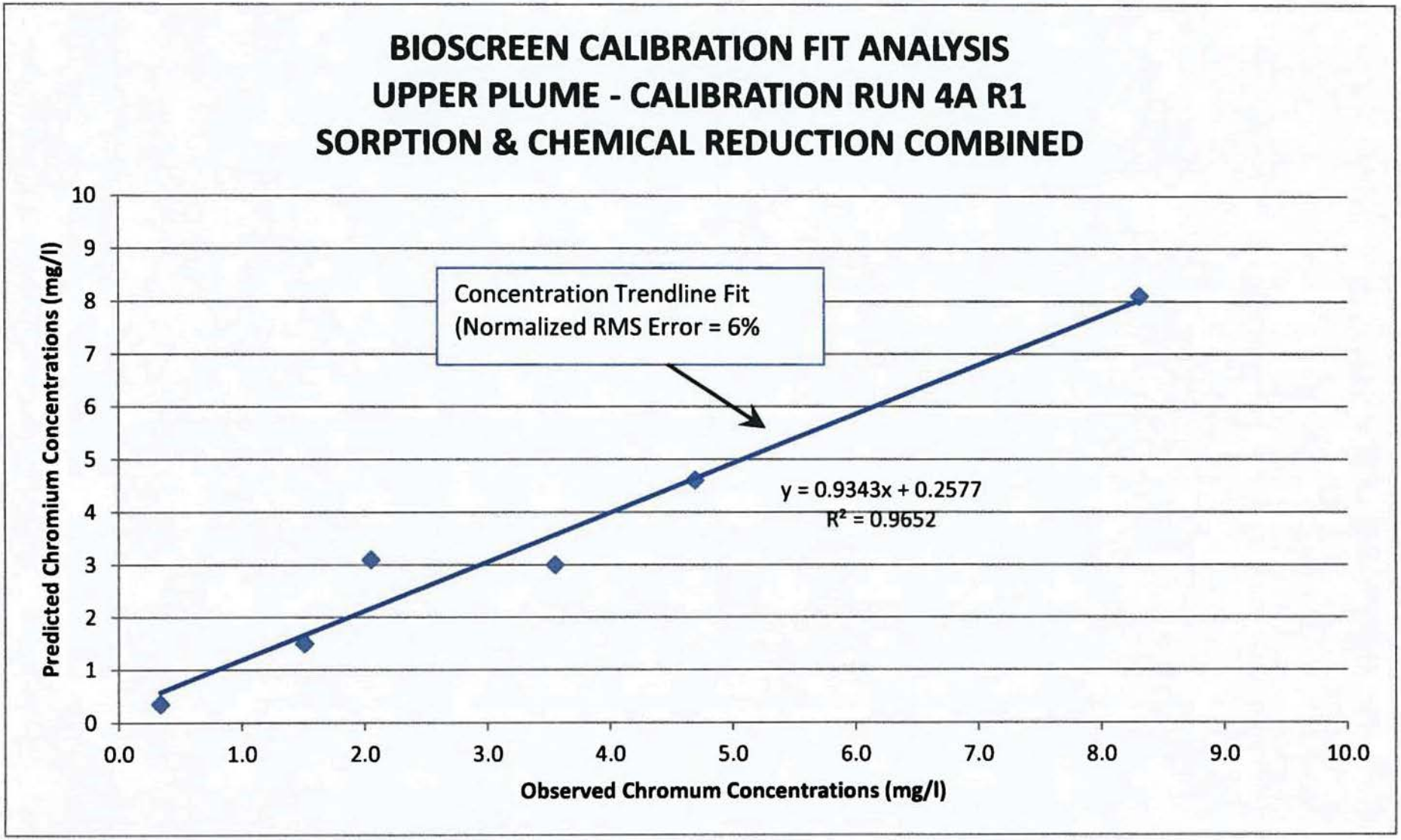
Model Calibration Run 4a r1 for Upper Plume	
Number of Monitoring Wells (n)	6
Mean Absolute Error (MAE)	0.32
Root Mean-Squared Error (RMSE)	0.49
Normalized RMS Error (NRMSE)	6%

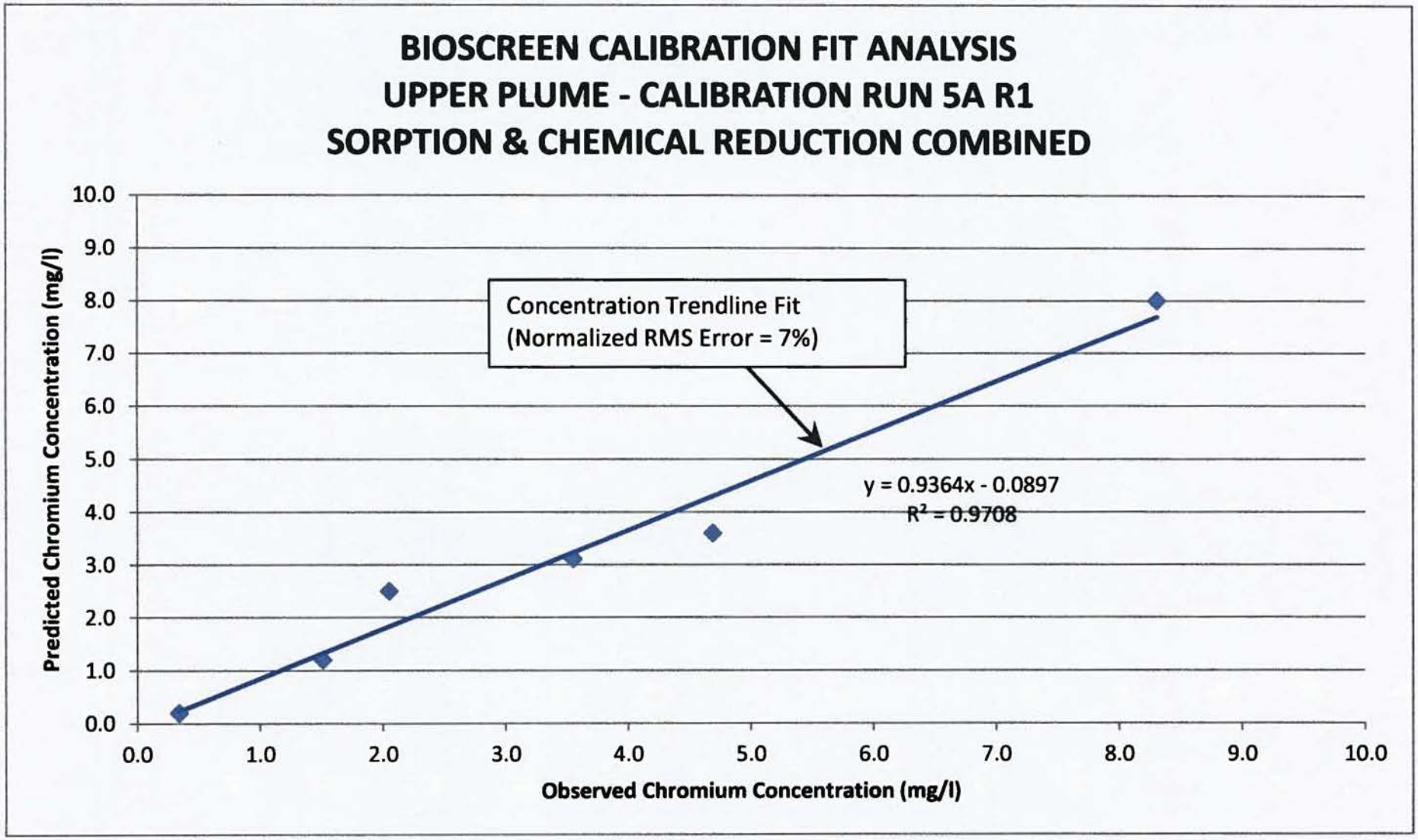
BIOSCREEN Calibration Run No.	Well ID	Observed Cr Concentration (mg/l)	Predicted Cr Concentration (mg/l)
5aR1	U7-B	8.3	8.0
	U8-B	4.7	3.6
	U7-A	3.6	3.1
	U8-C	2.1	2.5
	U8-E	1.5	1.2
	U7-D	0.3	0.2

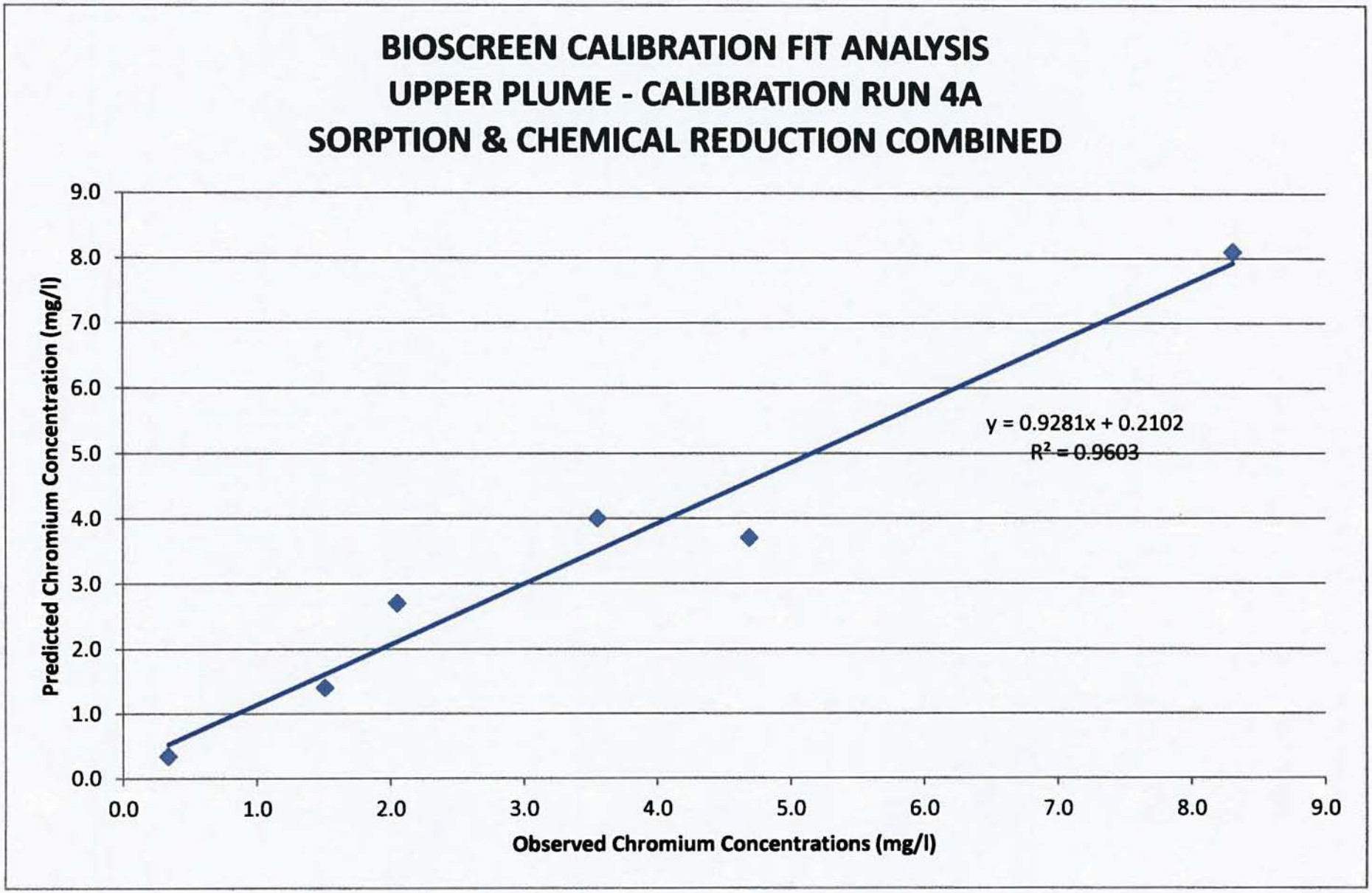
Model Calibration Run 5a r1 for Upper Plume	
Number of Monitoring Wells (n)	6
Mean Absolute Error (MAE)	0.46
Root Mean-Squared Error (RMSE)	0.55
Normalized RMS Error (NRMSE)	7%

BIOSCREEN Calibration Run No.	Well ID	Observed Cr Concentration (mg/l)	Predicted Cr Concentration (mg/l)
4a	U7-B	8.3	8.1
	U8-B	4.7	3.7
	U7-A	3.6	4.0
	U8-C	2.1	2.7
	U8-E	1.5	1.4
	U7-D	0.3	0.3

Model Calibration Run 4a for Upper Plume	
Number of Monitoring Wells (n)	6
Mean Absolute Error (MAE)	0.40
Root Mean-Squared Error (RMSE)	0.53
Normalized RMS Error (NRMSE)	7%


BIOSCREEN CALIBRATION FIT ANALYSIS
UPPER PLUME - CALIBRATION RUN 4A R1
SORPTION & CHEMICAL REDUCTION COMBINED
Concentration Trendline Fit
(Normalized RMS Error = 6%
y = 0.9343x + 0.2577
R² = 0.9652
Predicted Chromium Concentrations (mg/l)
Observed Chromum Concentrations (mg/l)
0
1
2
3
4
5
6
7
8
9
10
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0


BIOSCREEN CALIBRATION FIT ANALYSIS
UPPER PLUME - CALIBRATION RUN 5A R1
SORPTION & CHEMICAL REDUCTION COMBINED
Predicted Chromium Concentration (mg/l)
Observed Chromium Concentration (mg/l)
Concentration Trendline Fit
(Normalized RMS Error = 7%)
y = 0.9364x - 0.0897
R² = 0.9708
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0


BIOSCREEN CALIBRATION FIT ANALYSIS
UPPER PLUME - CALIBRATION RUN 4A
SORPTION & CHEMICAL REDUCTION COMBINED
Predicted Chromium Concentration (mg/l)
Observed Chromium Concentrations (mg/l)
y = 0.9281x + 0.2102
R² = 0.9603
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0

Attachment 6
Statistical Analysis of Calibrated BIOSCREEN Model
Lower Plume
Sorption and Chemical Reduction Simulated as
Combined Bulk Attenuation Process
Shieldalloy Site
Newfields, New Jersey

Zone	BIOSCREEN Calibration Run No.	Well ID	Observed Cr Concentration (mg/l)	Predicted Cr Concentration (mg/l)
Lower Zone	5	L7-C1	12.1	12.3
		LPW-8/LPW-9	10.5	8.8
		L8-B1/B2	3.4	6.3
		L7-E1/E2	5.1	5.8
		SC-5D	0.7	1.4

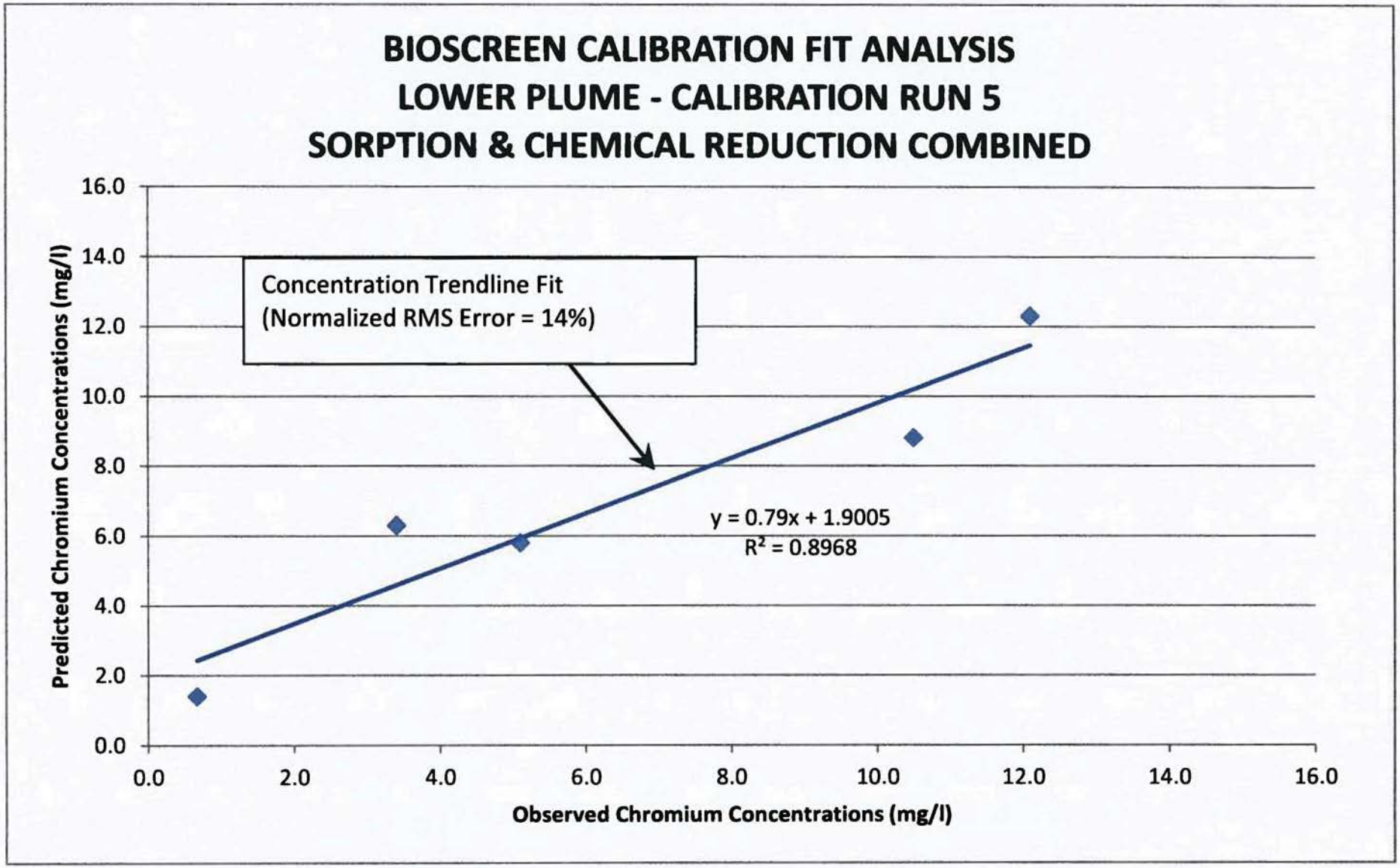
Model Calibration Run 5 for Upper Plume	
Number of Monitoring Wells (n)	5
Mean Absolute Error (MAE)	1.25
Root Mean-Squared Error (RMSE)	1.57
Normalized RMS Error (NRMSE)	14%

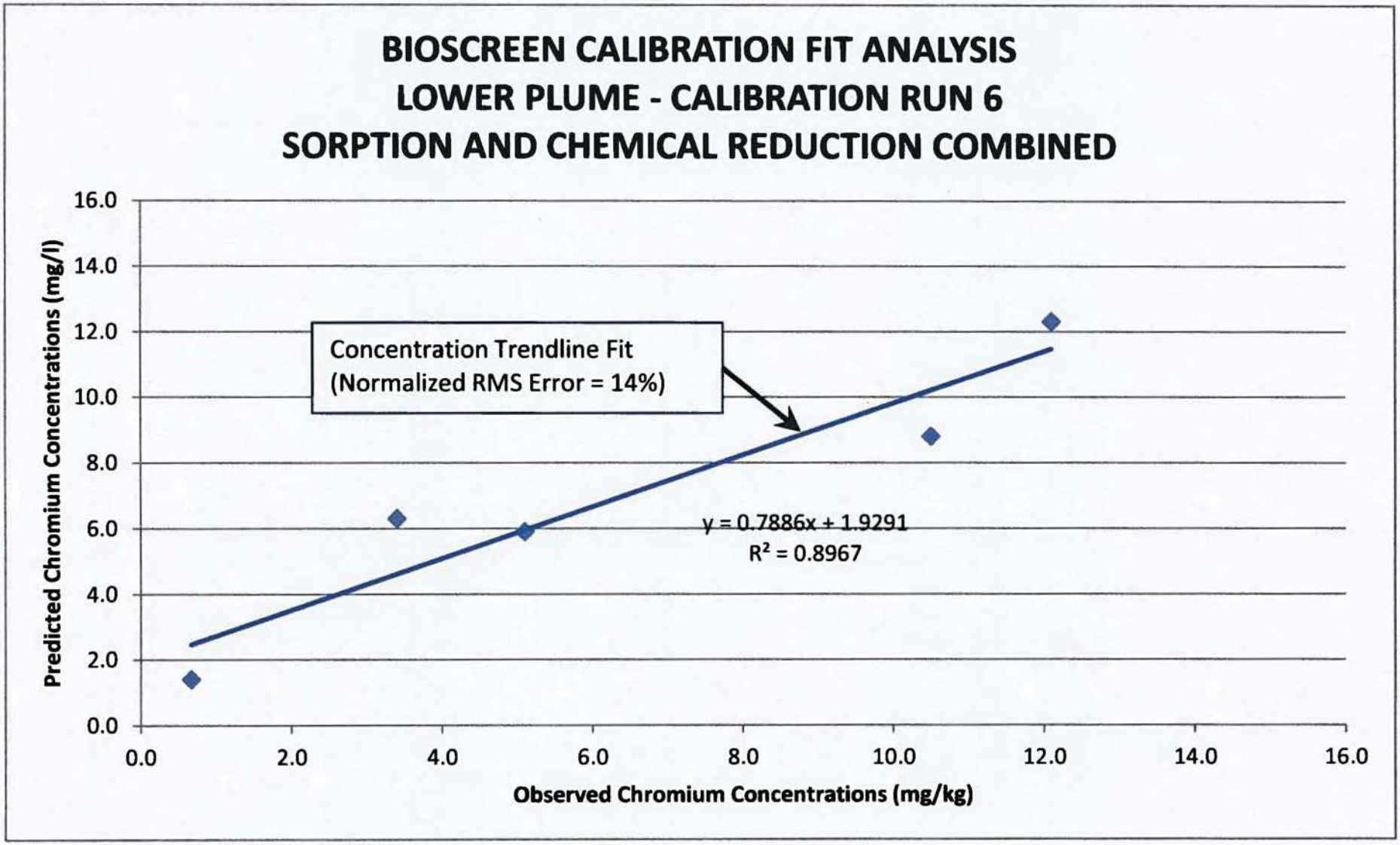
BIOSCREEN Calibration Run No.	Well ID	Observed Cr Concentration (mg/l)	Predicted Cr Concentration (mg/l)
6	L7-C1	12.1	12.3
	LPW-8/LPW-9	10.5	8.8
	L8-B1/B2	3.4	6.3
	L7-E1/E2	5.1	5.9
	SC-5D	0.7	1.4

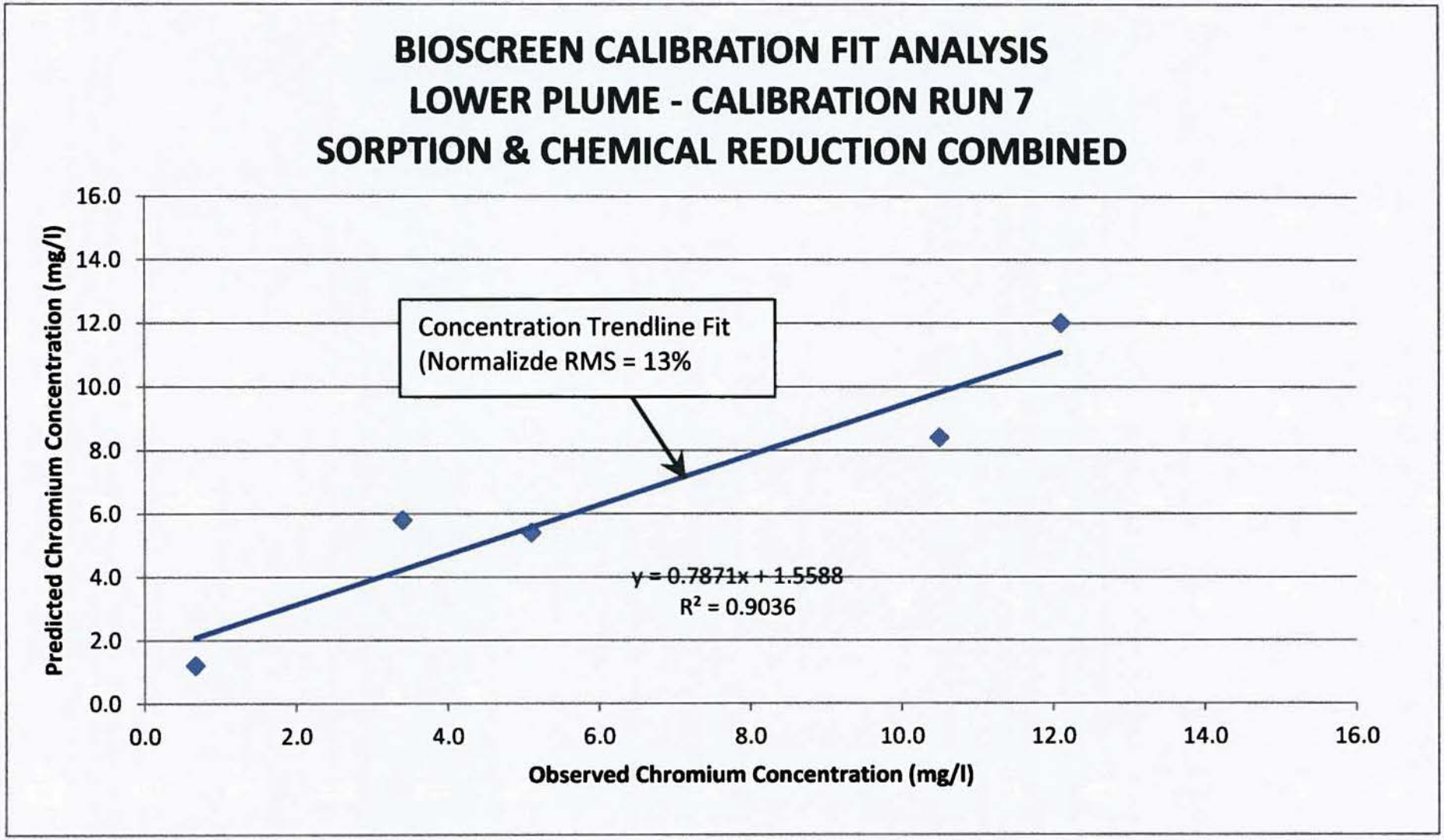
Model Calibration Run 6 for Upper Plume	
Number of Monitoring Wells (n)	5
Mean Absolute Error (MAE)	1.27
Root Mean-Squared Error (RMSE)	1.58
Normalized RMS Error (NRMSE)	14%

BIOSCREEN Calibration Run No.	Well ID	Observed Cr Concentration (mg/l)	Predicted Cr Concentration (mg/l)
7	L7-C1	12.1	12.0
	LPW-8/LPW-9	10.5	8.4
	L8-B1/B2	3.4	5.8
	L7-E1/E2	5.1	5.4
	SC-5D	0.7	1.2

Model Calibration Run 7 for Upper Plume	
Number of Monitoring Wells (n)	5
Mean Absolute Error (MAE)	1.09
Root Mean-Squared Error (RMSE)	1.45
Normalized RMS Error (NRMSE)	13%


BIOSCREEN CALIBRATION FIT ANALYSIS
LOWER PLUME - CALIBRATION RUN 5
SORPTION & CHEMICAL REDUCTION COMBINED
Concentration Trendline Fit
(Normalized RMS Error = 14%)
y = 0.79x + 1.9005
R² = 0.8968
Predicted Chromium Concentrations (mg/l)
Observed Chromium Concentrations (mg/l)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0


BIOSCREEN CALIBRATION FIT ANALYSIS
LOWER PLUME - CALIBRATION RUN 6
SORPTION AND CHEMICAL REDUCTION COMBINED
Predicted Chromium Concentrations (mg/l)
Observed Chromium Concentrations (mg/kg)
Concentration Trendline Fit
(Normalized RMS Error = 14%)
y = 0.7886x + 1.9291
R² = 0.8967
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0


BIOSCREEN CALIBRATION FIT ANALYSIS
LOWER PLUME - CALIBRATION RUN 7
SORPTION & CHEMICAL REDUCTION COMBINED
Predicted Chromium Concentration (mg/l)
Observed Chromium Concentration (mg/l)
Concentration Trendline Fit
(Normalizde RMS = 13%
y = 0.7871x + 1.5588
R² = 0.9036
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0